ABSTRACT

LAWRENCE, GENEVIEVE. Digital Printing and Traditional Surface Design Techniques. (Under the direction of Dr. Traci May-Plumlee (Chair) and Dr. Cynthia Istook (Co-Chair))

The use of digital fabric printing in textile and apparel companies is increasing. Continuing research on increasing color quality, speeding up production rates, development of new inks, and increasing the number of print-heads will facilitate adoption of this technology. Though digital printing has not yet reached its full potential, it offers many opportunities for new and innovative textile design techniques. To date, there has been little documented exploration into the design possibilities afforded by digital fabric printing.

The purpose of this research was to determine if the aesthetic qualities associated with the traditional hand surface design techniques of batik and discharge could be achieved using graphics programs and digital printing technology. During the research, digital batik and discharge fabrics were created and evaluated by both non-experts and experts. First, literature was reviewed to gain expertise in surface design, batik, discharge, printing methods, industrial production of batik and discharge, digital printing, and evaluation of aesthetics. The aesthetic qualities of batik and discharge were defined through hands-on exploration of the techniques in conjunction with critical evaluations from fellow artists. Evaluation tools were developed for batik and discharge based on the defined aesthetic qualities. Handcrafted and digital batik and discharge fabric samples were evaluated by non-expert and expert subjects. The digital samples were successfully created through graphics programs and digital printing. The analysis of the evaluations showed that the digital batik and digital discharge samples were successful in achieving a majority of the aesthetic qualities associated with handcrafted batik and handcrafted discharge.

DIGITAL PRINTING AND TRADITIONAL SURFACE DESIGN TECHNIQUES

by
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DEDICATION

This work is dedicated to my mother Mary Lawrence the most selfless, loving, and compassionate person I will ever know.

BIOGRAPHY

The author, Genevieve Lawrence, was born in Atlanta, Georgia on February 16, 1978. Her parents are Rick and Mary Lawrence (deceased) and she has four sisters Kristi Gottlob, Jessica Lawrence, Rebecca Lawrence, and Pamela Lawrence.

Genevieve graduated from Ayden Grifton High School in 1996. She received her Bachelor of Science Degree in Textile and Apparel Management(Apparel Concentration) from North Carolina State University, College of Textiles in 2000.

Genevieve has professionally exhibited her works in painting, fabric, and clothing mediums. She began her Master's of Science Program in 2000 at NC State, College of Textiles. She is currently pursuing a Master's of Science in Textiles with a concentration in Design.

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CHAPTER ONE: INTRODUCTION

Digital printing is an important technology to the future of textile printing. Some of the areas where digital printing excels are in the availability of unlimited colors, production of photo quality images, ability to capture three-dimensional qualities, quick response to change, and a shortened time from concept to sample. Due to these areas of excellence, digital printing holds great potential for new and innovative design ideas. But, it hasn't been fully integrated into textile and apparel companies due to slow production rates. Because of limited use, the potential for digital design has yet to be explored.

Handcrafted products have an aesthetic quality that many consumers find appealing. Currently, surface designers create one-of-a-kind handcrafted fabrics that can be found in art galleries, museums, specialty stores, etc. The limited availability and cost of these products keeps them from reaching many consumers. This project was performed to determine if the aesthetic qualities present in traditional surface design could be created in digitally printed fabric, and to establish the techniques used to create these digital designs. The development of digital printing onto fabric allows the possibility of bringing handcrafted qualities to the everyday consumer. Digital printing also offers a new design tool to the world of surface design.

1.1 PURPOSE OF STUDY

The objective of this research was to determine if the aesthetic qualities associated with the traditional hand surface design techniques of batik and discharge could be achieved using graphics programs and digital printing technology.

This objective was broken down into two specific research questions to guide the work.

Research Question One:

What methods and techniques can be used to achieve the aesthetic qualities of traditional batik and discharge using graphics programs and digital printing?

Research Question Two:

How well do samples of batik and discharge created with graphics programs and digital printing represent the aesthetic qualities associated with traditional batik and discharge?

1.2 RATIONALE

Digital technology is becoming more available, and will play an increasingly important role in the textile and apparel industries in the future. The research to date on digitally printed designs is limited. It is important that research is conducted to explore design possibilities, advantages, techniques, and limitations of digital printing technology for textile products.

Handcrafted products are valued throughout the world, but they are complicated to make and to produce them in large quantities requires a large amount of time and money. The creation of products with handcrafted qualities through digital means will reduce the time, money, and chemicals needed. The qualities of handcrafted products hold value to consumers, so creating products with the aesthetic qualities of handcrafted products will add value to the products. Digital printing also enables the distribution of products with handcrafted aesthetic qualities to large markets.

1.3 LIMITATIONS

The digital batik and discharge samples used in this project were created by one designer; therefore, the samples don't represent the variety of design capabilities available with all designers. Also, when evaluating samples based on aesthetic properties there is always some level of bias. The samples in this project were evaluated on defined aesthetic qualities associated with batik and discharge, but visual qualities like color, design, and hand may have biased the evaluations.

Another limitation of the project was the printer used in the final samples. The Stork Amber printer is a piezo printer, so thermal and continuous digital printing technologies are not represented in this project. The Amber is also limited in color gamut, because it only uses six colors of the same concentration.

The last limitation was the fabric used in printing the final samples. The fabric was not identical to the standards used in the evaluation tool, so the difference may have affected the evaluations. The areas of difference that may have affected the evaluations were hand, luster, and color. Since fabrics dye and print differently, the identical colors couldn't be achieved on the standards and digital samples.

CHAPTER TWO: LITERATURE REVIEW

2.1 SURFACE DESIGN

Surface design is the coloring, patterning, structuring, and transformation of fabric, fiber, and other materials (Surface Design Association, 2002). Printing is a common technique used to create colored patterns on fabric. Vidyasagar (1998) defines textile printing as creating designs on fabric for ornament. There are many approaches to printing fabric, but all textile printing can be divided into four classes or styles which are explained in the following sections.

2.1.1 PRINTING CLASSES

The printing class refers to the type of printing rather than the design or the chemical process. Vidyasagar (1998) describes three main classes of printing consisting of direct, resist, and discharge, while Storey (1992) describes an additional class, dyed. Vidyasagar (1998) incorporates the dyed class into the direct class by defining dyed as a variation of the direct printing class.

2.1.1.1 RESIST

To print with a reisist process, a material (paste, wax) is applied to the fabric to prevent dye from penetrating the fabric surface. The area in which the resist is applied remains its original color through further color applications. Resist and dyed printing are the oldest forms of textile printing. (Vidyasagar, 1998; Storey, 1992)

2.1.1.2 DISCHARGE

Discharge printing involves the removal of color from a dyed fabric. In discharge printing a chemical is applied to the fabric in the form of a pattern. The chemical then removes the color leaving white areas of fabric. The removal of color is difficult to control in discharge printing. So, when discharge printing is done without scientific calculation and precise chemical formulation, the removal of color will vary. This process is aesthetically similar to prints in the resist class. Modern day discharge involves the addition of illuminating dyes, which allow treated areas to be discharged and colored simultaneously while maintaining dark backgrounds. (Vidyasagar, 1998; Storey, 1992)

2.1.1.3 DIRECT

Direct printing, as the name implies, is applying color directly to the fabric using pigment or print paste. Direct printing is not to be confused with direct dyeing in which liquid dyes are applied to the fabric. In direct printing, designs are applied to selected areas of the fabric with a thickened color. (Vidyasagar, 1998; Storey, 1992)

2.1.1.4 DYED

Dyed printing is often categorized under the direct method, but Storey separates direct printing and dyed printing because dyed printing uses liquid dyes and the direct class uses pigment or print paste. In addition the dyed class is often described as a variation of the direct because a mordant must be applied to the fabric for the dye to adhere to the surface. Mordants are required to attach the dyed to the fabric surface. Areas of the fabric in which the mordant was not applied will not take the dyestuff. (Storey, 1992)

These four printing classes provide a broad overview of how printing methods are characterized. Within each class there are many specific surface design techniques used to design fabric. The next sections review two of these techniques in detail. Batik and discharge are two of the oldest methods of fabric printing and fabrics are currently being produced by these methods in factories, studios, and homes. Batik and discharge printing both began as hand methods of designing fabric, developed into industrial printing applications, and remain popular decorative methods for textiles and apparel.

2.1.2 BATIK

Batik is a resist class printing method and surface design technique used to design fabric. Batik is traditionally a handcrafted process that started over 1, 500 years ago (Fraser-Lu, 1986). Hot, liquid wax, consisting of paraffin wax, beeswax, or a combination of the two, is applied to a fabric. The fabric is then dyed, and the wax acts as a resist preventing selected areas of the fabric from absorbing dye. The process of waxing and dying is repeated several times forming a multicolored image on the fabric.

The wax resist in a batik often cracks when it hardens and cools. During the dying process, dye seeps into the cracks creating an effect referred to as cracking or veining. The amount of cracking, if any, can be controlled by the type of wax, number of waxings, and disturbance to the waxed fabric. If the fabric is folded, twisted, or manipulated after the wax has hardened it will cause increased cracking. When the design is finished, the wax is removed through boiling or ironing.

The methods by which the wax is applied and removed, dyes used, patterns, and motifs vary. In many areas of the world batik is an important part of the culture, and each region has its own methods and designs. Batik continues to be a popular fabric printing technique and can be seen in clothing, home textiles, hung on walls in the form of batik paintings, and used in textile art collages. Most batik found in clothing is imitation batik and handcrafted batik created using textile industrial machinery and processes.

Handcrafted fabrics that are available to consumers are expensive and often difficult to find.

2.1.2.1 HISTORY OF BATIK

Batik remnants have been found all over the world. Therefore, it is difficult to determine where the art form originated. The most common school of thought is that batik began in Asia or India, and then spread to surrounding areas and later to the west (Spee, 1982). The earliest samples of batik were found in Egypt dating around the 5th or 6th century A.D., but early batik samples have also been found in Peru, South America, and Japan (Spee, 1982).

Regardless of disagreement surrounding the origin of batik, most authorities agree that Java, Indonesia was one of the most important regions to the development and popularity of batik. When batik began in Indonesia, it was reserved for royalty and aristocracy. Royal Indonesian women had the time and design expertise to perform the batik process, but probably did so with the assistance of court artisans (Fraser-Lu, 1986).

The batik tradition spread slowly to surrounding areas. Around the sixteenth and seventeenth century, the popularity of batiks in the west increased dramatically. The first interest in batiks as an import came from the Arabic countries, then Portuguese, English and Dutch (Spee, 1982). Dutch travelers noted seeing ships filled with "fabrics decorated with colorful patterns" (Fraser-Lu, 1986, p.2). At this time, all batiks were hand-made using tjantings and brushes (Storey, 1992). Tjantings are copper cups with one or more

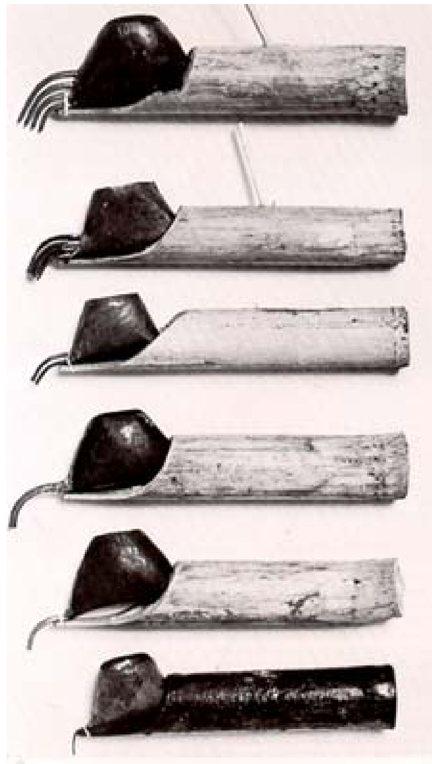


Figure 1: Tjantings
(Spee, 1982)

spouts attached to bamboo handles. Handling the tjantings required skilled laborers and was very time consuming. Around the 18th and 19th centuries, silk batiks became so popular in France and England that governments passed decrees "forbidding the wearing of this material. This was done in order to protect their own woolen and silk industries" (Spee, 1982, p. 18).

Due to the popularity of batik fabrics, the English and the Dutch began to work on batik imitations. English imitations were as expensive as batiks created by hand, so they were not every successful (Spee, 1982). The Dutch approach was to bring people over from Java to teach the Dutch textile industry about batik processes and techniques. The Dutch used knowledge gained from the Javanese to develop an imitation batik process which involved printing directly onto fabric with engraved copperplates and rollers.

These imitations were only printed on one side of the fabric, but provided a cheap alternative to the hand made batiks.

Imitation batiks continue to be produced today. The Dutch have the longest history in imitation batiks, but there is also a history of wax printing in Africa. Wax printed batiks from Africa are called "African" or "West African" prints (Storey, 1978). African and Dutch wax prints are the most widely known, but African style wax printing is also done in France and Japan .

Due to increasing demand and competition from European imitations, it was necessary for the countries that produced authentic batik to try and simplify their handcrafted batik processes. The need for increased speed in handcrafted batik brought about the invention of the tjap (Storey, 1992). A tjap is a block which "consists of strips

Figure 2: Tjap
(Spee, 1982)

of soldered copper, and is open on the back" (p.16). The process of using a tjap to apply the wax resist is similar to stamping. To get the wax onto the tjap, the wax is first applied to a pad of fabric and then the tjap is pressed into the pad. This change in the production process allowed the batiker to produce in one day what usually took three months with the tjanting. The invention of synthetic dyes also made the batik process faster. When dyeing with natural dyes, the process could take several weeks (Spee, 1982). Synthetic dye allowed the dyeing process to be shortened to hours and minutes. Numerous artisans worldwide and small batik factories in African and Asian countries still create batik more or less by hand (Miles, 1981).

2.1.2.2 HANDCRAFTED BATIK METHODS

The following sections provide an overview of the traditional methods of creating batiks and the modern western methods. Indonesia, particularly the region of Java, is well known for its batiks. Therefore the Indonesian batik process was chosen to represent traditional methods.

2.1.2.2.1 INDOESIAN/JAVANESE BATIK METHODS

Indonesian batiks are traditionally created on finely woven cotton, or sometimes silk (Fraser-Lu, 1986). The fabric may be purchased already prepared for printing, or otherwise purchased fabric must scoured and washed to remove any finishes. In Javanese batiks, scoured and washed fabrics are usually cut and sewn into the end products before the batik design process begins (Spee, 1982). Once the fabric is ready for printing, a starch is applied to prevent the wax from penetrating too deeply. Depending on the experience of the batik artist, a pattern may or may not be sketched onto the fabric before the wax is applied. The wax is applied with a tjanting to both sides of the fabric (Clark, 1977). A characteristic of high quality batiks in Java is applying wax to both sides of the fabric which guarantees that the designs and lines are sharp. Waxing both sides of the fabric considerably increases the time required to create the batik, therefore it is not done in all areas of the world (Spee, 1982). The temperature of the wax effects how much it runs when applied, so maintaining a constant temperature is important.

Before the wax is applied to the fabric, the cloth is stretched across a "gawangan"

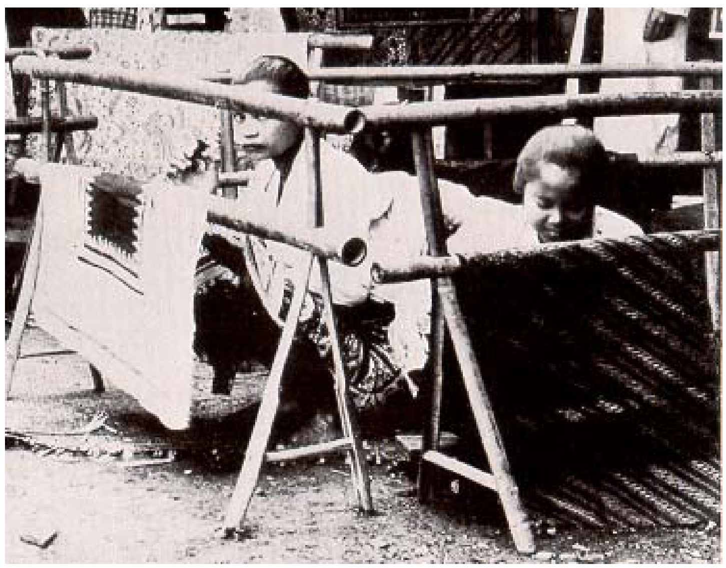


Figure 3: Gawangan
(Spee, 1982)

to keep the fabric taut (Fraser-Lu, 1986). A gawangan is "a frame with cross bars of wood or bamboo, over which the cloth is placed" (Spee, 1982, p.48). When creating larger batiks, the fabric is stretched across a table padded with fabric and either the tjap, or a combination of the tjap and tjanting are used to apply the wax (Clarke, 1977). When a large area of the fabric needs to be waxed, the batik artist may make a brush called a jegul by wrapping fabric around a small stick (Spee, 1982).

Figure 4: Jegul
(Spee, 1982)

The next step is the first dyeing of the fabric. In Java the first color applied is usually indigo (blue) (Fraser-Lu, 1986). The dyes used depend on the fabric type and desired look, but today synthetic dyes are the most common (Spee, 1982). The fabric is either dipped into a dye bath or the dyes are directly painted onto the fabric. After the dye is applied the fabric is washed and dried between applications of wax. Then, another layer of wax is drawn onto the fabric, the fabric is dyed a second color, and washed. To avoid cracking, re-waxing occurs in any areas that have begun to crack (Clark, 1977). The dyeing, washing, and waxing process is repeated for all colors in the design. The final colors in batik designs are results of over-dyeing. Each dye step in the process affects the previous color. The over-dyeing process used in batik creates fabrics with rich and saturated colors.

Once the layers of color are complete, the wax must be removed from the fabric. The wax is removed by placing the batik in boiling water. In the boiling process, the wax melts and rises to the top of the water where it is removed to prevent it from reattaching to the fabric. Usually soda ash is added to the water to boost the removal of the wax (Spee, 1982). After all of the wax is removed, the fabric is washed and air dried in a shaded spot.

2.1.2.2.2 BATIK WAX

The wax used for batik depends on the effects desired. A crackled effect is very appealing to the western world, but cracking made the traditional Indonesian batik inferior (Robinson & Robinson, 1970). Beeswax is the traditional wax used in Indonesian batiks. If cracking is a desired effect, then paraffin wax is mixed with the beeswax. The more paraffin wax that is added, the more cracking that will occur (Clark, 1977). The type of wax used is also influenced by the tool used to apply the wax. Indonesian batik artists use multicolored wax in their designs to make it simpler to distinguish between layers (Spee, 1982).

2.1.2.2.3 BATIK MOTIFS

The motifs of Javanese batiks are usually symbolic in subject matter and traditional in form. They can be divided into three groups, which are background designs, geometric designs, and non-geometric designs. Batik designs that originate from any of the three groups are considered traditional. Background designs are simple patterns developed from dots, lines, squares, crosses, foliage, or flowers (Fraser-Lu, 1986). Geometric patterns are similar to textile repeating patterns. Some examples of geometric patterns are circular, weaving, parallel diagonal, patchwork, and triangular to name a few. Non-geometric patterns are traditionally symbolic and ornamental. Subject matter of non-geometric batik motifs includes birds, butterflies, heraldic devices, and floral patterns (Meilach, 1973). There are over 3,000 traditional batik designs in existence (Fraser-Lu, 1986).

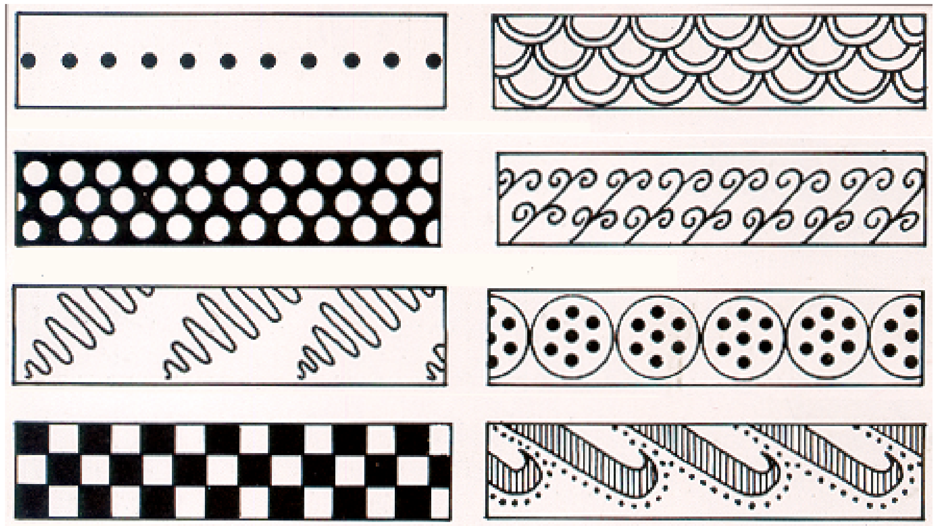


Figure 5: Background designs
(Spee, 1982)

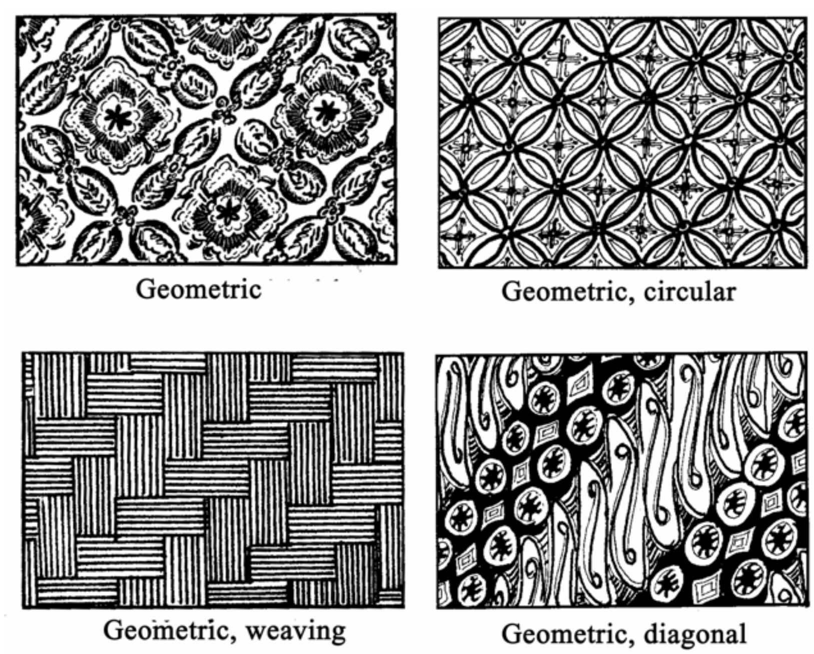


Figure 6: Geometric designs
(Fraser-Lu, 1986)

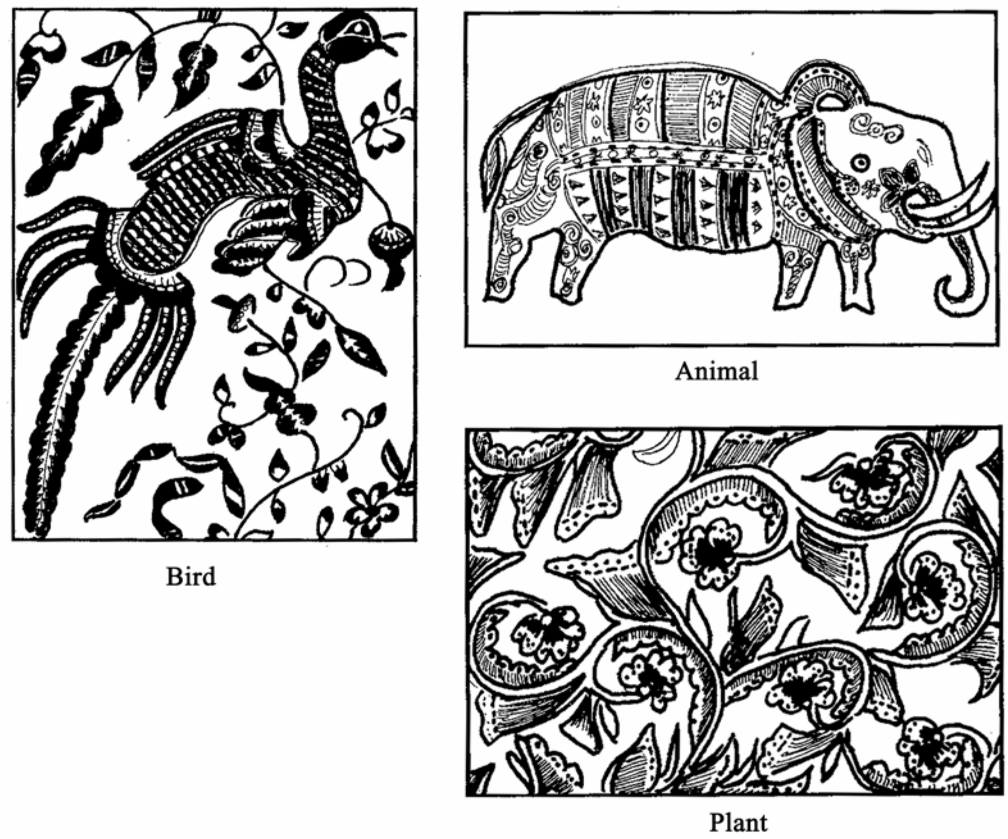


Figure 7: Non-geometric designs
(Fraser-Lu, 1986)

2.1.2.2.4 MODERN BATIKS

Batiks are currently created by artists and amateurs. For some it is a hobby, craft, or pastime; for others it is their chosen medium for artistic expression. In modern batiks "the trend is to decorate the fabric any way the artist envisions; to apply design by any method, traditional or innovative, even depart from standard procedures" (Meilach, 1973, p.13). Artist and amateurs use traditional tools along with modern tools. A modern improvement on the batik process is the development of electric tjantings which allow the

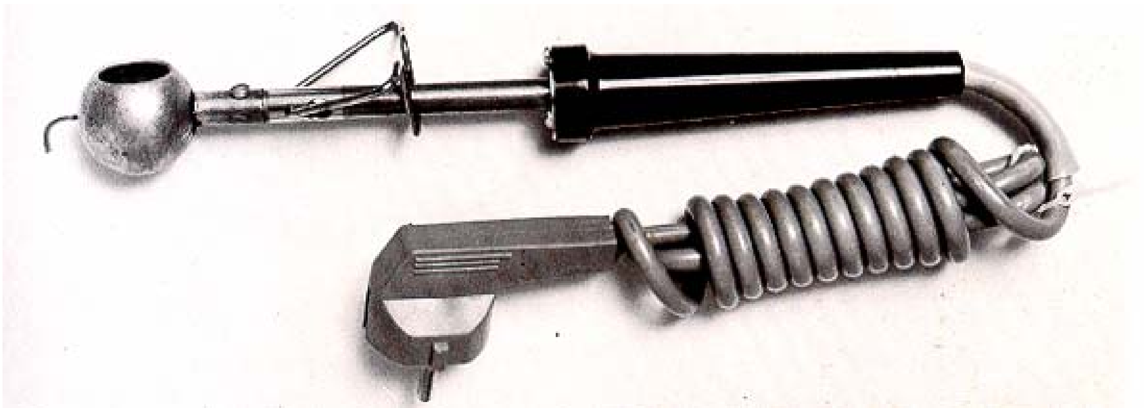


Figure 8: Electric tjanting
(Spee, 1982)

flow of the wax to be adjusted. Modern batik is often used in combination with other surface design methods. Batiks can be found in clothing, draperies, sculptures, lamps, wall hangings, and in many other end uses.

2.1.3 DISCHARGE

Discharge, along with resist methods like batik, is one of the most ancient forms of textile surface design (Miles, 1981). Discharge is a method of creating designs on fabric by removing color from a pre-dyed or printed fabric. A discharge paste composed of a reducing agent is applied to the fabric. The reducing agent either "withdraws oxygen from or adds hydrogen to other substances" triggering the removal of color (Storey, 1978, p.139). The discharge paste causes the dye to break down resulting in removal of color. The removal of color can be partial or complete depending on the dyes, chemicals, and desired effects.

Discharge printing was developed to take advantage of the richness and saturation of color of dyed fabrics, while achieving a light printed image. Discharge printing provides deeper, darker background colors than are possible with screen or roller printing

(Vidyasagar, 1998). Discharge also offers better quality than direct methods like blotch or screen printing when creating delicate or intricate patterns.

2.1.3.1 HISTORY OF DISCHARGE

The earliest documented discharge printing was done by a man named Monteith in 1802. The discharge agent used in the 'Monteith' process was a chlorine solution (Storey, 1978). To create the discharge print, the fabric was placed between two metal plates with 'perforated designs'. The chlorine solution was poured onto the plates. Because the plates were held tightly together, the solution was only able to penetrate the fabric through the 'perforated designs'. The discharged fabric was then washed and the finished product was called a "bandana".

Other early industrial discharge prints were made by removing indigo dyes through oxidization, reduction, or using chlorine to bleach out the colors (Miles, 1981; Storey, 1978). Daniel Knoechlin, of France, was the first person to achieve both white discharge and colored discharge on the same fabric (Storey, 1978). He found that he could create an illuminating dye solution which was unaffected by the discharging agent. Knoechlin added illuminating dyes to the discharge agent and was able to simultaneously remove the dyed color from a fabric and recolor it with the illuminating dyes (Anderson, 1999). Today most discharge prints are created with vat dyes and the reducing agents 'Fomosul', 'Rongalite', or 'Redusol' (Storey, 1978). The current discharge printing process requires pre-dying, application of a reducing agent, and steaming. The Italian textile industry is widely recognized for its experimentation and work in discharge printing today. Surface designers also produce discharge prints, though in much lower volume. Surface designers usually use discharge printing in combination with other surface design techniques.

2.1.3.2 HANDCRAFTED DISCHARGE PRINTING

Handcrafted discharge printing doesn't have as rich of a history as handcrafted batik. Most information on handcrafted discharge printing can be found in how-to crafts books intended for new or experienced surface designers. In handcrafted discharge, the desired effect varies from designer to designer. Some designers enjoy the variety and unpredictability discharge offers, while others prefer to control the process. To control discharge printing requires a complex process and specific chemistry. For those less concerned with controllability, a commonly used discharge agent is household bleach (Laury, 1997). Household bleach only works on natural fibers and can damage silk and wool. There are companies that provide professional surface designers access to chemicals like Rongalite, so the designers may mix their own discharge paste. Mixing the discharge paste allows the designer to have more control over the end results. These companies also offer pre-mixed discharge pastes to be used with specific dyes and fabrics.

The first step in the discharge printing process is the application of the paste to the fabric. The discharge paste used in discharge printing allows the designer to choose from a variety of application methods. The paste can be thickened or thinned to meet the requirements of the application method. Surface designers can apply the discharge paste by painting, stamping, screen-printing, using a resist method, spraying, or any tool available in the studio. After the discharge paste dries, heat is applied to the fabric causing the paste to completely react with the fabric. Steam is a common source of heat used in discharge printing. Once the discharge paste has reacted completely, the fabric is washed to remove access paste and color. Discharge printing is commonly used in combination with other techniques. For example, a designer may discharge a fabric then screen print text over the discharged areas. Handcrafted discharge printing is found in clothing, accessories, quilts, and textile artwork.

2.2 PRINTING METHODS

Most, if not all, printing techniques began as hand processes and were then converted to mass production capabilities. There are still a few traditional techniques used for printing in the textile and apparel industries, but they are performed by very small scale production firms and usually for specialty items. Twenty percent of all manufactured fabrics are printed, the remainder are dyed, yarn dyed, or produced white (Achwal, 1995). This section focuses on printing processes that are used for production in the textile printing industry.

2.2.1 BLOCK PRINTING

Block printing is a direct method of applying color to textiles. It involves, as the name implies, the use of blocks with patterns carved out of them. Block printing dates back to the middle ages, and is still used in very small amounts today (Vidyasagar, 1998). It is used mainly in Europe for printing on scarves and handkerchiefs. Due to the handcrafted skills required to create them, high costs are associated with these specialty-printed fabrics. In block printing there are few limits on the number of blocks, or the size of the pattern.

2.2.1.1 HAND BLOCK PRINTING

When creating a block print, a layer of waterproof cloth is usually placed under the fabric to protect the fabric from dirt (Storey, 1992). Then a layer of cotton fabric, called a back-grey, is stretched on top of the waterproof layer. The back-grey is used to absorb excess dye and prevent any blurring. Next, the fabric to be printed is spread tightly across the table. A device called a “swimming tub” or “sieve” is used to apply the color to the block. After a block is placed on the fabric, it then must be hit with a mallet which transfers the color onto the fabric. Each time the block or blocks are placed on to the fabric they must be registered to insure the correct alignment (Vidyasagar, 1998). For each color in the design a separate block must be used.

2.2.1.2 AUTOMATED BLOCK PRINTING

Like many hand printing techniques, attempts were made to automate block printing (Vidyasagar, 1998). The first mechanized block printing machine was called the surface roller machine (Storey, 1992). The surface roller machine used “rollers made of wood and the patterns [were raised] in relief as with the hand block” to apply the color to the fabric (Vidyasagar, 1998, p.185). These machines were difficult to operate, because the wooden rollers warped and split easily (Storey, 1992). Later a man named Burch improved the machine by making the rollers from copper. The next attempt to automate block printing produced a machine called Perrotine, named after the creator. “This machine mechanically performed all the actions of the blockprinter, that is it put color on the sieves, transferred it to the blocks, stamped the blocks on the cloth and then moved the cloth forward after each repeat” (Storey, 1992, p. 50). The Perrotine was used up until 1946 in Germany.

2.2.2 SCREEN PRINTING

Screen printing is classified as a resist method of applying color to a surface. Screen printing is different than other resist methods. Screen printing is different because screens are created using a resist method, but the actually application of color to the fabric is direct. In the first step of creating a screen, a fine silk is stretched across a wooden or metal frame (Yates, 1996). The screen is then sensitized with a light reactive liquid that hardens on the screen (Vidyasagar, 1998). Next, the desired image is applied by placing the image on the screen and exposing it to light. The area of the screen covered by the image isn't exposed to light, and the unhardened substance can be removed with warm water from the unexposed areas. A screen must be created for each color in a design (Yates, 1996). Registration is important to insure the quality of the printed design. If the screens are not properly registered, the colors may overlap and the image could be distorted.

2.2.2.1 HAND SCREEN PRINTING

A screen print is created by placing the screen face down on the substrate and forcing dye paste through the open areas of the screen (Yates, 1996). The dye paste can only be applied to the substrate through the open areas of the screen. The dye paste consists of the appropriate dye for the substrate, a fixative if needed, and thickener (Clark, 1977). The hand method of screen printing is seldom used for volume production because it is labor intensive, making it an expensive process (Yates, 1996). Small quantities are not expensive to produce through hand screen printing since the initial costs of creating the screens are low. Most hand printing is done by small-scale specialty printers.

2.2.2.2 AUTOMATIC FLAT BED SCREEN PRINTING

Since the beginning of screen printing, efforts were made to make it faster and more automated (Storey, 1992). Some printers use mechanical aids like automatic printing tables, screen lifters, and mechanized cloth movement. In the most automated version of flat bed screen printing, the fabric is attached to a belt and conveyed along the printing surface while printing screens raise and lower automatically. Each time a screen is lowered into position, a squeegee mechanically applies the dyestuff. Automating flat bed screen printing decreased its cost, allowing for more experimentation in design, and enabled the designs to reach a larger market (Albeck, 1969). Just as in hand screen printing, a separate screen is required for each color in the design. Therefore, the table must be long enough to accommodate the total number of screens required for the design.

Flat bed screen printing is faster than hand printing, but is still considered slow in terms of production rates. It is most often used for production runs around 2,000 yards or less. An advantage is that flat bed screen printing also supports larger repeat sizes than rotary or roller printing. (Yates, 1996; Albeck, 1969)

2.2.2.3 ROTARY SCREEN PRINTING

Rotary screen printing is similar to flat bed printing in that the fabric is conveyed along a table, but in rotary printing the design is applied to the fabric by cylindrical aluminum mesh screens (Yates, 1996). The screens turn with the fabric and continuously print by forcing the dye paste inside the cylinder out through open areas of the mesh. Just as in hand and flat bed printing, a separate screen is required for each color in the design. Rotary printing is the fastest screen printing method and is the most commonly used printing method in the world (Yates, 1996; Gordon, 1997). The production run capabilities are slightly smaller than roller printing, and screens are less expensive to prepare than roller printing rollers (Yates 1996; Albeck, 1969). Rotary printing can produce larger repeat patterns than roller printing along, with offering greater flexibility of design and precision in registration. (Yates, 1996; Albeck, 1969, Gordon, 1997; Belck, Butler, & Wamhoff, 1990)

2.2.3 ROLLER PRINTING

Roller printing uses rollers with designs carved into them to transfer the images to fabric continuously (Belck, Butler, & Wamhoff, 1990). Roller printing was once the most commonly used printing method, but its use has decreased due to improvements in rotary screen printing (Yates, 1996). Like many other methods, roller printing requires a separate roller for each color in the design. Printing rollers are copper and usually 7" in diameter, but the maximum circumference is 16" (Yates, 1996; Vidyasagar, 1998). The average number of rollers on a printing machine is 6, but some print as many as 16 colors (Vidyasagar, 1998).

Rollers can be engraved by hand, machine, or chemical methods. Hand engraving is time consuming, expensive, and requires specialized skills. Machine engraving involves first putting the repeat pattern in relief onto a soft steel roller that is then hardened (Vidyasagar, 1998). The hardened steel roller is pressed against the copper roller to create a design. Chemical engraving involves coating the copper roller with a wax or varnish. The repeat pattern is etched out of the coating, and then acid is applied to cut the design into the roller (Storey, 1992).

The actual printing process is set up with the engraved copper rollers surrounding a central cylinder. The width of the fabric and the number of colors in the design determine the size of the central cylinder. The rollers turn and cause the cylinder to turn. The fabric runs in-between the cylinder and the engraved rollers. The dye paste can be applied directly to the engraved rollers or it can be applied using unengraved rollers called "color furnishers" (Yates, 1996). The dye paste attaches itself to the engraved areas of the roller and then transfers onto the fabric. The central cylinder is padded with several layers of fabric along with a blanket and back-grey (Vidyasagar, 1998).

Today, roller printing is most commonly used to print apparel fabric. Creating the engraved rollers is time consuming and expensive, so it is only profitable to use roller printing when printing several thousand yards (Yates, 1996). This much yardage in one design is not usually printed for home furnishing or contract fabrics. Roller printing can create fine lines and color tones, but the size of the engraved roller limits the repeat size (Gordon, 1997). In roller printing changing of designs requires the rollers to be changed. The rollers are large and time consuming to change, making roller printing inflexible especially when quick turn-around is necessary. Off grain printing is a common problem in high-speed roller printing if the process is not properly monitored.

2.2.4 TRANSFER PRINTING

Transfer printing is very different from the methods previously discussed. Transfer printing is a process that uses heat to convert dyes into gas to transfer them to a different substrate (Storey, 1992). This process is known as sublimation, and only disperse dyes are capable sublimating. Disperse dyes have an affinity for synthetic fibers, so transfer printing can only be done on certain synthetics or heavily synthetic blends.

The basic process of transfer printing involves printing the design onto the appropriate paper, placing the paper with the printed side against the final fabric, and applying heat to trigger the sublimation process. When the dyes are in the gaseous state they have stronger affinity for the fabric than the paper, so they transfer to the fabric. Once the dyes have cooled on the fabric, they return to their original solid state.

Transfer printing increases design possibilities because there is no limitation on the number of colors in a design. Almost anything that can be printed on paper can be transferred to fabric. Transfer printing is useful for printing knit and stretch fabrics because it can prevent the distortion that can occur when using traditional methods. Transfer printing accounts for about 4% of all textile printing worldwide (Gordon, 1997). One reason transfer printing accounts for such a small percentage of the printing industry is the limitation in fabric options. Most printing is done on cotton or cotton blended fabrics, which are inappropriate for transfer printing. Transfer printing is mainly used to print specialized products, knit or stretch fabrics, and T-shirts.

2.3 ADDITIONAL PRINTING METHODS

2.3.1 FLOCK PRINTING

Flock printing is a process used to apply dyed or undyed short fibers to fabric using an adhesive (Wingate, 1975). The adhesive is applied to the substrate either all over or in a specific pattern (Elsassar, 1997; Clark, 1977). It is important to choose an appropriate base fabric and adhesive for the fibers being attached (Clark, 1977). The fibers are arranged on the fabric vertically, either mechanically or by a method called electrostatic flocking (Elsassar, 1997). "Electrostatic flocking uses an electrical charge to orient the fibers vertically. Electrostatic flocking is slower than mechanical, but provides more luxurious flocking" (Elsassar, 1997, p. 247). Printing the adhesive by rotary screen printing or flat-screen printing methods gives the best flock printing results. These methods can apply a thick film of adhesive to the fabric (Clark, 1977).

2.3.2 PHOTOGRAPHIC PRINTING

In photographic printing, a design is applied to a roller and the roller applies it to the fabric. To create a design on the roller, a contact print is made of a photograph. The contact print is then placed onto the copper roller and a sensitizing solution is applied. A powerful light source is applied causing the sensitizing solution to heat up and attach the print to the roller. In the next step the roller is washed and all areas not affected by the light are removed. The film left behind acts as the guide for the design being etched. Once the design is etched into the roller, the remaining film is removed. (Wingate, 1975)

2.3.3 POLYCHROMATIC PRINTING OR JET PRINTING

Polychromatic printing is a computerized printing method that uses small jets to apply dye continuously to fabric (Wingate, 1975; Elsasser, 1997). The jets inject color into the fabric and control how the design is applied (Hollen, Kadoplh, Langford & Saddler, 1993). The machine "consists of a series of horizontal bars containing the dye" (p.340). The fabric passes under the bars and the dye is applied to the proper place from the jets on the bars. This method makes multi-colored striped patterns possible (Wingate, 1975). The size of the nozzles, number of jets, and dye used determine the detail possible in the design (Hollen, Kadoplh, Langford & Saddler, 1993). Polychromatic printing is commonly used to print carpeting, pile upholstery fabrics, toweling, and some apparel fabrics.

2.3.4 DUPLEX PRINTING

Duplex printing is a process of printing both sides of fabric simultaneously (Belck, Butler, & Wamhoff, 1990). Duplex machines use either cylinder screens or engraved rollers to apply designs to the fabric (Storey, 1992). When Duplex printing is done using engraved rollers, the dye paste is applied in the same manner as with traditional roller printing. Duplex roller printing differs from roller printing in that the fabric moves between two sets of rollers creating an identical or totally different pattern on both sides (Belck, Bulter, & Wamhoff, 1990). Engraved rollers are used to make Duplex prints, but screen Duplex printing is the most recognized (Storey, 1992). The most successful screen Duplex machine is called the Aljaba Duplex machine. The Aljaba aligns the cylinder screens vertically in pairs. The fabric runs in between the screen pairs creating the image on both sides. Duplex print designs are usually large, simple shapes with large areas of black or dark texture. The designs are created like this to hide any inaccurate matching of patterns. Duplex printing is usually done on very stable and heavy fabrics, mostly for home furnishings.

2.4 INDUSTRIAL PRODCUTION OF BATIK

Currently, batik is produced many ways, depending on where it is being made. Batik is being produced in small Javanese, Chinese, and Indian towns, in the studios of textile artists, and in mass at textile printing companies. There are significant differences between the colors, styles, and qualities of the batiks being produced. The techniques used to produce imitation batiks are not often discussed. Most textile printing companies keep this information private. In the book titled <u>Textile Printing</u> (1981), Berry and Ferguson discuss five main categories related to the mass production of batiks. The categories are real wax prints, Java prints, green-ground prints, imitation wax prints, and fancy prints. Java prints, green-ground prints, and fancy prints are primarily categorized by their distinguishable colors and patterns. There are no descriptions for how fancy prints and green-ground prints are created. Fancy prints are described as "displaying none of the characteristic features of wax prints," and green ground prints "strongly resemble the Java Prints" (Berry & Ferguson, 1981). In both Java Print and green-ground print the emphasis is on color. To create Java prints, the fabric is over-printed following the resist printing process. Real wax prints and imitation wax prints display some of the characteristics associated with traditional batik.

2.4.1 REAL WAX PRINTS

African real wax prints are currently the closest industrial approach to imitating genuine batik. "Few details of the process involved in printing west African wax prints have been published, since the firms involved regard such 'know-how' as a very important part of their business" (Clark, 1977, p.228). The wax, more commonly rosin, is applied using "special duplex machinery" to print on both sides of the fabric (Miles, 1981). Containers or color boxes holding the rosin are heated to insure that it is maintained in the molten state required for application (Miles, 1981; Clark, 1977). After the fabric is printed with rosin, it "is quenched in cold water so that the rosin solidifies and the sharpness of detail is maintained" (Miles, 1981, p. 226). It is important to remember that the fabric can't be dried through heat or dyed with hot water because the rosin would melt.

Batik has a characteristic look described as marbling, veining, or crackle. In real wax prints this effect is created deliberately, by tumbling the fabric in cold water causing the rosin to crack (Miles, 1981). When the dye is applied to the design, it penetrates through the cracks creating the crackle effect. Another characteristic of real wax prints is a halo or half-shadow on one side of the fabric where the print was not registered correctly. This halo is sometimes present in traditional batik because the design is waxed on both sides and is not always exactly aligned. Due to the extent of waxing, washing, dyeing, and drying that take place in real wax prints, the fabric becomes distorted, as does the design. With each step, registration of the design becomes more difficult, so the second and any additional colors "are almost exclusively printed by means of blocks or screens" (Miles, 1981, p. 226). The process is said to comprise of 15 to 20 operating steps and a mixture of traditional and modern printing techniques (Hilden, 2001). Real wax prints are very involved and complicated; therefore, they are expensive to produce, and few companies are involved in this market.

2.4.2 IMITATION WAX PRINTS

As the name implies, these prints are meant to imitate genuine batik prints, but imitation wax prints are produced without the use of wax. The designs are created with engraved rollers and commonly, duplex printing (Miles, 1981). Without the use of duplex printing imitation wax prints can be identified easily due to "being paler on the unprinted side than on the face side" (Clark 1977, p. 230). The veining effect is usually created in one of the following three ways; duplex printing, printing the veins on the back grey so the veins are on the back of the fabric, or through a separate printing operation (Miles, 1981). The halo effect is created in imitation wax prints by a separate printing operation in which an engraved roller prints the shadow around the edges of the motif.

This method of imitating batik is less expensive than real wax printing, but less authentic in appearance.

2.5 INDUSTRIAL PRODUCTION OF DISCHARGE PRINTS

In current textile discharge printing, the dyed fabric is called the ground shade. Modern discharge prints use a chemical reducing agent to destroy the ground shade and remove color (Clark, 1977). The discharge solution or paste that is used depends on the deconstruction requirements of the dye used in the ground shade (Miles, 1981). Industrial discharge printing is slightly different than handcrafted discharge in that the chemistry is more controlled. In industrial discharge printing, the goal is to remove color leaving a white pattern, but often additional dyes are added to the discharge pastes which are able to resist the discharging agent (Clark, 1977). These dyes are called illuminating dyes. Illuminating dyes are colored dyes which are unaffected by the discharge paste, leaving the discharged areas colored (Storey, 1978).

The discharge printing process involves mixing of the discharge paste, which consists of the appropriate discharging agent for the fabric and dyes being printed. The commonly used agents are ‘Fomosul’, ‘Rongalite’, or ‘Redusol’ (Storey, 1978, p. 141). Next, the paste is printed onto the fabric using a roller or screen, dried, and then steamed. This process causes the paste to destroy the ground shade (Anderson, 1999). The final steps, washing, soaping, drying, and finishing follow traditional fabric printing methods (Sharma, 1999).

The textile printing industry uses discharge printing for several reasons. Miles (1981) and Anderson (1999) identify four aesthetic advantages of discharge printing.

The advantages include; dark colors with depth, light, complex patterns on dark backgrounds, sharp edges, and avoidance of overlapping colors. For complete review of discharge advantages see Anderson (1999). From a design perspective, discharge prints are often more interesting in character and provide superior aesthetic effects to those of direct printing (Storey, 1978; Berry & Ferguson, 1981).

Discharge printing is superior to direct printing in several areas, but discharge printing began and remains a specialized sector in the textile market. Storey (1978), Anderson (1999), and Miles (1981) identify the following reasons for limited used of discharge: 1) it is expensive, specialized equipment is required, 2) the results are difficult to control, 3) removal of dyes generates large amounts of waste, 4) the reducing agent used can be hazardous, and 5) registration is difficult.

2.6 DIGITAL PRINTING

Frank Cost (1997) defines digital printers as "any printing device that inputs a digital data stream and outputs printed pages" (p.79). The textile and apparel industries primarily use inkjet digital printers. Inkjet printing “is a non-impact, dot-matrix printing technology in which droplets of ink are jetted from a small aperture directly to a specified position on a media to create an image"(Le, 1998, p. 50). Inkjet fabric printing is a process in which inks, made up of dyes, are placed onto the fabric surface creating an image. Each printer has a specified number of colors to print, so all other colors must be created through dithering. The dithering process places tiny ink drops, from the available colors, onto the fabric at different values to give the appearance of additional colors, simulating the appearance of the original image (Reinert, 2002).

2.6.1 INK JET PRINTING SYSTEMS

Ink jet printers are first categorized by the method used to form and apply ink drops to the fabric surface (Fralix, 2000). The two broad categories are continuous and drop-on-demand. In the continuous process ink drops are controlled by electrical charges. The drops pass through charging plates and then through an electric field which causes the charged drops to deflect and return to the jet recirculation system. The uncharged drops pass through the field and are applied to the media forming an image (Le, 1998).

The drop-on-demand process only sends ink drops through the jets when they are being used to form the image. The ink drops are sent through tiny openings and directly deposited onto the substrate (Cost, 1997). The drop-on-demand method is the most commonly used technology (Le, 1998). Within these broad categories, three specific types of digital printing systems are notable.

2.6.1.1 THERMAL INK JET PRINTING

Thermal ink jet printing is a drop-on-demand process. Thermal printing uses water-based inks that must have low viscosity, low surface tension, and vaporize quickly at their boiling point in order to perform. The ink is deposited into a small chamber with an opening on one end and a heated plate on the other. The ink is heated past its boiling point which causes a bubble to form in the chamber and eject a single ink drop through the opening. The chamber is then cooled, refilled and re-heated to repeat the process. (Cost, 1997)

2.6.1.2 PIEZO INK JET PRINTING

Piezo is a drop-on-demand process which uses a piezoelectric plate and an electric current. The ink reservoir is connected by a small passageway to the ink chamber, and a piezo plate is located on the ink chamber. An electric charge is sent through the piezo plate causing it to deform. The deformation of the plate decreases the space in the chamber causing a single ink drop to be ejected from the nozzle. (Cost, 1997)

2.6.1.3 CONTINUOUS INK JET PRINTING

Continuous ink jet as the name implies, is a continuous process. Continuous printing uses a piezo crystal to vibrate the nozzle causing the ink jet to break into droplets. The droplets are then pushed out of the nozzle by a pump (Cost, 1997). The droplets pass through charging plates and then deflection plates which cause the droplets to either be sent to the substrate or deflected back to the ink recirculation system.

2.6.2 DIGITAL PRINTING PROCESS

The steps involved in digital printing are chemical 1) pre-treatment of fabric, 2) physical preparation of fabric, 3) digital printing, and 4) post-treatment. The main purpose of the chemical pre-treatment is to fix the dyes to the fabric surface (Kulube & Hawkard, 1996). The pre-treatment is also used to control the spread of the ink drops as they encounter the fabric surface. The chemicals used in the pre-treatment solution are still being developed but for cotton fabrics it usually consists of a thickener, a carbonate and urea (Chapman, 2001). For silk fabrics an acid would be used in place of the carbonate. The dyes are chosen to be suitable for the fiber content of the fabric being printed. Below is a list of dyes matched with their appropriate fibers.

Table 1: Chemistry to Fiber	
Chemistry	Fiber
Acid Dyes	Silk, nylon, wool
Disperse Dyes	Polyester
Reactive Dyes	Cotton, cotton/poly
Pigments	All fibers

(Kane, J., & Work, R., 2000).

The physical preparation of lightweight fabrics usually involves backing the fabric with paper. The chemical treatment of the fabric generally makes it stiff, but many fabrics require additional stabilization to successfully feed through the printer. If the fabric is not properly stabilized, the print-head will strike the fabric ruining the image and cause the printer to clog. The paper backing is removed after the fabric is printed and before post-treatment.

The last step in the digital printing process is post-treatment. All dyes listed above, with the exception of pigment, required post-treatment steaming for the dyes to be permanently set in the fabric (Developments in Jet Inks for Textile Printing). Pigments require dry heat for setting (Developments in JITP). Once the fabric has been steamed, it is washed to remove excess inks and dried.

2.6.3 DIGITAL PRINTING IN THE TEXTILE AND APPAREL INDUSTRIES

Inkjet technology continues to develop in the textile and apparel fields driven by recent changes in the industry. The industry is moving toward shorter printing runs, increased flexibility, wide of production ranges, quicker time to market, more design changes per year, improved integration between design and production, and less dependence on seasons (Tippett, 2001; Barton, 2002; Watkins, 1997; Bohringer, 2000). Many in the industry feel that digital printing will support industry changes, but currently it falls short because digital printing can not be accomplished at standard production rates (Owen, 2000). Seiren, an apparel and automotive fabric manufacturer, was one of the first companies to digitally print at production-scale. Seiren developed its own digital printing technology, so their printers are not available for sale. Most commonly digital printing is used in textiles and apparel companies for proofing and sampling, personalization, customization, agile manufacturing, short-run and rapid-response manufacturing, and specialty niche items.

2.6.4 SURFACE DESIGN AND DIGITAL PRINTING

According to a survey done by the Craft Organization Directors Association, the fine crafts industry is a $14 billion dollar a year industry (CODA, 2001). Recently, these artists and crafts people have taken a keen interest in digital printing. For example, the Surface Design Association held a conference in 2000 focused on digital technology, including digital printing (Surface Design Association, 2002). A digital printing workshop recently conducted at North Carolina State University College of Textiles was attended entirely by members of the SDA and professional artists. There are many websites that offer information, techniques, and fabrics for in home or small studio digital printing. Products are being developed geared towards artists and crafts people. Companies are beginning to market products which can be used in conjunction with home printers to set standard printer inks to fabrics (Dharma, 2002). "Digital printing opens the door to a new field of designers and entrepreneurs who will enter the market offering unique and customized products" (Stork, 1999, p.21). The digital technology available to artists and crafts people is currently limited by price and flexibility. There is much room for development of printers, fabrics, and graphics software that is oriented toward this market.

2.7 EVALUTATION OF ART AND AESTHETICS

The topic of aesthetics is complex and heavily disputed among philosophers (Dickie, 1997). Modern philosopher George Dickie has written several books on the topics of aesthetics, art, value, and evaluation of art. In his books "Evaluting Art" (1998) and "Art and Value" (2001), he has developed a method for comparing and rating art based on aesthetic properties. Dickie explores theories developed by Ziff, Beardsley, Sibley, Goodman, Wolterstoff, Hume, Vermazen, and Urmsom in developing his method. He builds on the strengths of each philosopher's theory to develop his own theory of art evaluation. Dickie's theory differs from the other philosophical theories of art evaluation in that he designs a system for comparing pieces of art rather than just defining what makes an individual piece of art valuable. For a critical review of art evaluation theories see "Evaluating Art" (Dickie, 1998).

Dickie's theory of art evaluation is similar to other theories of art evaluation in that the first step is assessing what make a piece of art valuable. Other evaluation theories culminate in defining a piece as valuable, but Dickie's continues. Dickie's theory demonstrates that "value comparisons can be made between some but not all pairs of works of art" (Dickie, 2001, p. 78). For two pieces of art to be compared, the properties that make the art pieces valuable must be the same and be ranked in a manner that allows for evaluation. He provides the following example to illustrate pairs of work that can be evaluated against each other (Dickie, 2001, p. 79)

First work (A3, B2, C2)

Second work (A2, B1, C1)

In this example, A, B, and C represent identical properties and 1, 2, and 3 represent rankings of each property. The larger numbers indicate higher ranking. Because every property of the first work is ranked higher than the second, the first work would be valued higher than the second work. Dickie then provides the following example of works that can't be comparatively evaluated.

Third work (A3, B2, C1)

Fourth work (A1, B2, C3).

The third and fourth pieces of work can't be evaluated as a whole against each other because A, B, and C are all the properties that make the art piece valuable and neither piece is ranked higher in at least two properties (Dickie, 2001). Though the last two pieces can't be compared in sum, they can be comparatively evaluated on the individual properties. To summarize, Dickie's theory allows for the comparison of art pieces both in total and to individual properties when the aesthetic properties that provide value are the same and the rankings allow for a comparison.

CHAPTER THREE: METHODOLOGY

The purpose of this research was to determine if the qualities of handcrafted batik and discharge could be recreated through digital means and digital fabric printing. The methodology used to address this objective is presented in two sections. The first section describes the methods used for investigating digital production of batik and discharge, and for producing samples of batik and discharge. The second section defines the methods used to evaluate the success of the digital samples. It includes the research sample, development of an evaluation tool, data collection method, and the data analysis method.

3.1 PART 1: DEVELOPMENT OF DIGITALLY CREATED SAMPLES

A total of eight digital samples were created; four digital batik samples and four digital discharge samples. Digital fabric samples were created using Adobe PhotoShop and Pointcarrè software on a PC platform, and with a WACOM graphics tablet. The printer used was the Stork Amber CMYK printer using reactive dyes and six of the seven print-heads. The process of creating the final samples included designing, printing, evaluating, modifing, and reprinting until the digital fabric samples were satisfactory. A Xorella, autoclave steamer was used for the post-treatment process. The steps in the digital sample development are described in the following sections.

3.1.1 HAND EXPERIMENTATION

The first step was hands-on exploration with batik and discharge. Creating hand samples using both techniques provided deeper understanding of the aesthetic qualities related to each. Experiencing the procedures and the effects first hand was beneficial and essential to recreating the techniques through other means. Important knowledge gained from working with the hand samples included a better understanding of the colors resulting from hand dying of fabrics. Later, when working with the digital samples, this experience with hand dying helped to determine colors for digital samples.

3.1.1.1 BATIK

Batik is a process that involves many layers of waxing and color. Working with the batik wax gave a clear understanding of how the wax is applied to the fabric and what happens when the wax comes in contact with the fabric. Repetition of waxing and dyeing helped later in digital exploration to recreate the color layering process involved in batik.

3.1.1.2 DISCHARGE

When discharge paste is applied to hand dyed fabrics, they discharge to a variety of colors. Some colors of fabrics consistently discharge to the same color each time the process is repeated. Other colors discharge inconsistently, and the resulting color depends on the dyes that made-up the ground color. Working with the hand discharge samples enabled educated decisions to be made when determining what colors should represent the discharged areas in the digital samples.

3.1.2 DEFINING AESTHETIC QUALITIES OF BATIK AND DISCHARGE

Through the literature review, interviews, and hands-on experimentation with samples, a vocabulary was developed to describe aesthetic qualities of batik and discharge. This development happened with the help and evaluation of fellow artists and surface designers. It was important to establish definable aesthetic qualities which could be used in later evaluation of the digital samples. These aesthetic qualities were also essential to the digital experimentation, so that the objectives for creating the digital samples were known.

3.1.3 DIGITAL EXPERIMENTATION

Digital exploration was a development process that involved continuous comparison of digital and hand samples. The digital batik and discharge samples were developed in conjunction with critical evaluations from fellow artists. The refinement of the descriptions and definitions of batik and discharge aesthetic qualities descriptions continued throughout the digital experimentation and sample making process. It was important for the descriptions of the qualities to continue to develop. Because the differences between handcrafted samples and digital samples became more obvious as work progressed, the definitions and qualities could be more clearly defined.

3.2 PART 2: EVALUATION OF DIGITAL SAMPLES

3.2.1 SAMPLE DEVELOPMENT

To best evaluate the success of the digital samples it was determined that the research sample should consists of two groups of evaluators. The population was segmented into experts and non-experts. Then, a purposive sample of 40 evaluators was drawn consisting of 20 surface design experts and 20 non-experts. Surface design experts were defined as members of the Surface Design Association, textile artists, or textile art educators. The purpose of the expert group was to provide an evaluation of the digital samples from the perspective of a trained eye and extensive experience with handcrafted fabrics. Half of the expert evaluators were members of the Surface Design Association (SDA), “an international not-for-profit organization, dedicated to the promotion of, as well as education and critical thinking about surface design” (Surface Design Association, 2002). The membership consists of approximately “3000 independent artists, designers for industry, educators, scientists, manufacturing technicians, entrepreneurs, curators, gallery directors and students" (Surface Design Association, 2002). This organization also publishes a peer reviewed monthly journal titled *Surface Design.* The remainder of the experts were textile artists or textile art educators.

For stratification purposes, non-experts were defined as anyone not a member of the SDA, textile artist, or textile art educator. The purpose of the non-expert group was to provide an evaluation of the digital samples from the perspective of an untrained eye and minimal, if any, experience with handcrafted fabrics.

3.2.2 DEVELOPMENT OF EVALUATION TOOL

An evaluation tool in the form of a survey was developed specifically for this study. The objective of the evaluation tool was to determine whether the digital batik and discharge samples accurately represented the qualities of the handcrafted batik and discharge samples. The evaluation tool was designed through literature review, interviews, critical evaluation during experimentation, and visual observation of discharge and batik samples. A textile conservationist, a museum curator, and a textile collection database director were interviewed to establish if there were standard practices or methods for evaluating batik and discharge textiles. From the interviews, it was determined that there were no standard practices or methods for evaluating batik and discharge textiles. Each textile professional interviewed used personal knowledge and experience along with literature resources when evaluating batik and discharge textiles.

To begin development of the evaluation tool a list of aesthetic qualities was developed. The list was based on the literature review, critical evaluation, and visual observations, and the shared personal knowledge of textile professionals. The list of aesthetic qualities was developed with input from with several designers who critiqued the development of the digitally printed samples. The lists of qualities and their definitions appear below.

Batik Aesthetic Qualities

Cracking or Veining: The liquid wax cools and cracks, so during the dyeing process the dye penetrates the small cracks creating a cracking or veining effect.

Waxy lines/patterns: Because patterns are created with hot, liquid wax, the lines and patterns that result have a flowing liquid quality.

Halos around images: Slightly darker or lighter outlines often appear around lines and patterns.

Saturation of color: The areas that absorb dye are wet through with color.

Image on both sides of the fabric: Wax is typically applied to both sides of the fabric so that image is created on both sides.

Discharge Aesthetic Qualities

Dark backgrounds with light patterns: Discharge is typically used to create light images on dark backgrounds.

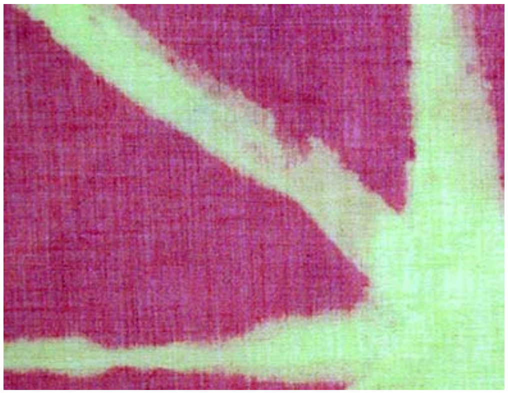
Distinct pattern edges: Edges of patterns are usually crisp and patterns are easily identifiable in discharge fabrics.

Removal of color leaving stained patterns: An additional design effect that can be created through discharge is partial removal of color creating stained patterns.

Saturation of color: The dyed areas of the fabric are wet through with color.

Varied removal of color: Discharge often varies in the amount of color removal, so the overall design may consists of white patterns along with a variety of color stained patterns.

The evaluation tool required respondents to evaluate each technique independently. It was divided into three sections for each technique being evaluated. Part one required the evaluator to indicate whether he or she was familiar with the technique being evaluated. Knowledgeable evaluators were then asked to mark qualities they felt were important to the appearance of the technique being evaluated. Part two required evaluators to rate hand and digital samples of each technique individually on a 1 to 5 scale according to how well each represented each quality considered. Part three required the evaluators to compare digital samples to handcrafted standards based on the same qualities as used in the previous section. A scale ranging from 1 (not at all) to 5 (as well as the standard) allowed respondents to indicate how well each digital sample represented each quality seen in the standards. The standards were chosen to represent professional handcrafted textiles. The batik standards were hand crafted in Egypt by professional batik artists. A surface designer handcrafted the standards for the discharge fabrics. The batik and discharge standards (Figures 9, 10, 11, 12, 13, 14, 15, and 16) can be found on the following pages.



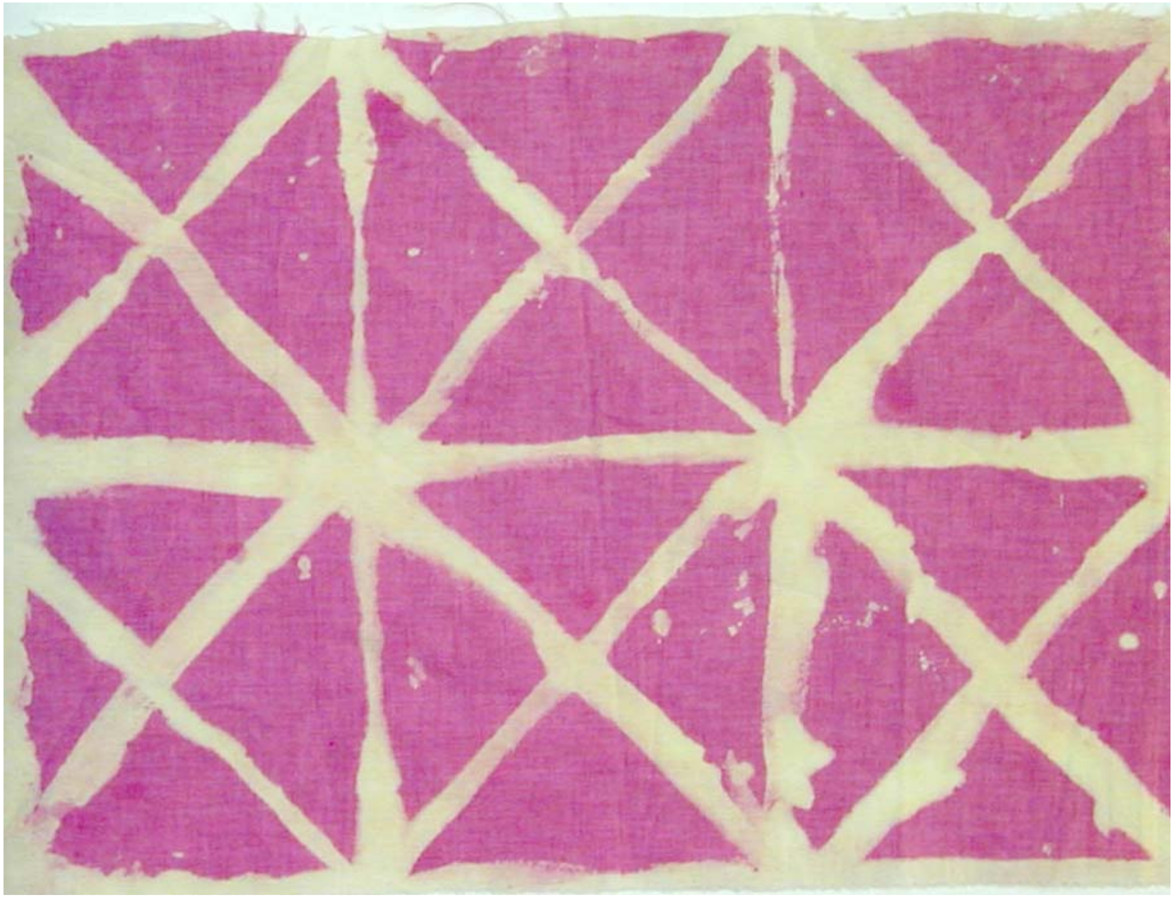


Figure 9: Handcrafted Discharge Standard

Figure 10: Handcrafted Discharge Standard

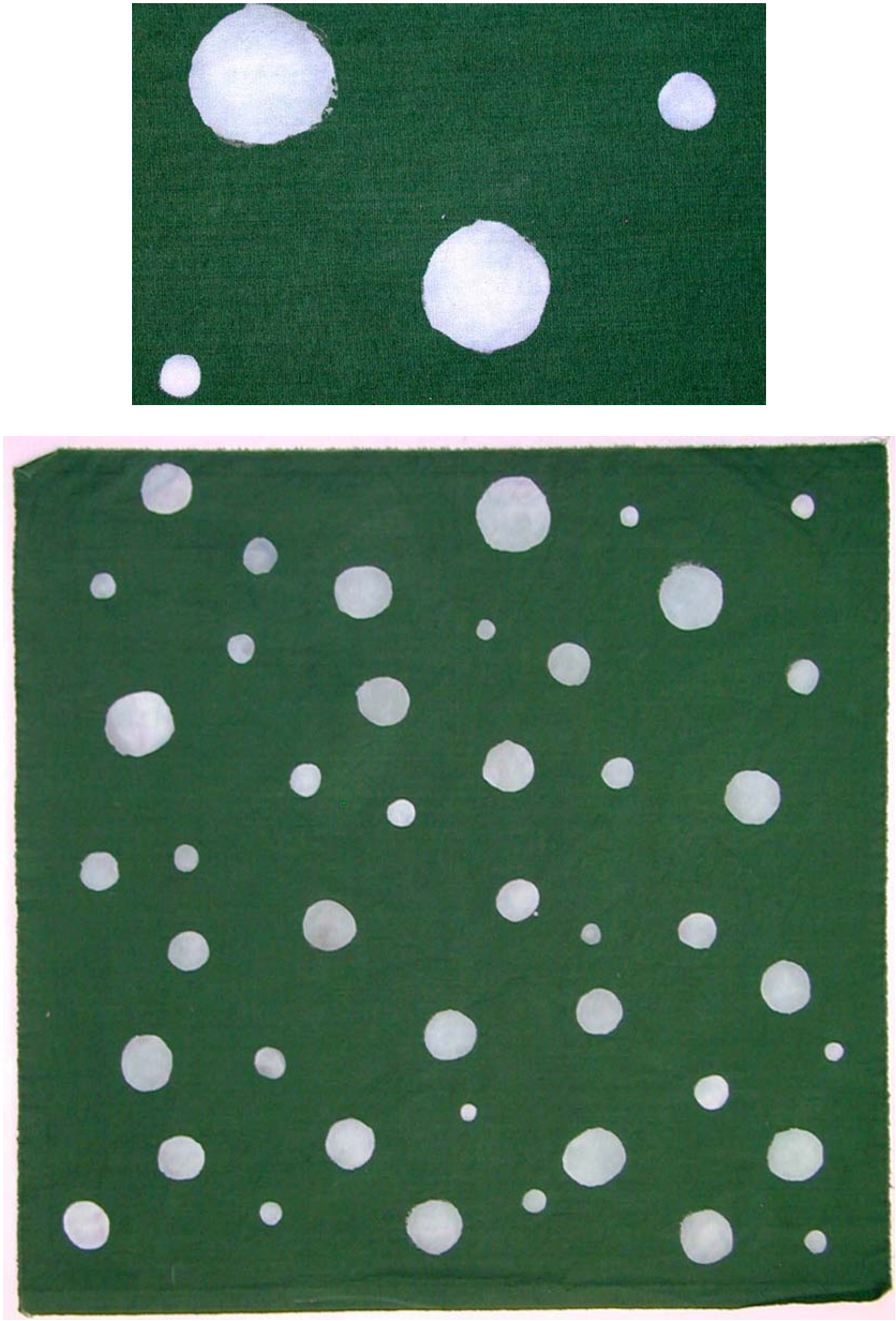


Figure 11: Handcrafted Discharge Standard

Figure 12: Handcrafted Discharge Standard

Figure 13: Handcrafted Batik Standard

Figure 14: Handcrafted Batik Standard

Figure 15: Handcrafted Batik Standard

Figure 16: Handcrafted Batik Standard

At the end of the survey the evaluators were asked to provide demographic information to be used to further describe the research sample. The evaluation tool was pilot tested. The pilot test was conducted by the prime researcher on an individual basis with five textile and apparel research faculty members and one design faculty member. Following revisions based on the pilot testing, it was determined to be appropriate for the study. The evaluation tool can be found in Appendix A.

3.2.3 DATA COLLECTION METHOD

Collecting the data in the form of a survey allowed research participants to visually inspect, handle, and rate fabric samples according to developed criteria. The survey was given on an individual basis by the prime researcher. Fabrics were presented to the participants mounted on boards attached only at the top of the samples. This allowed participants to handle the fabrics. The fabric samples were also shown to the research participants in random order to prevent any order bias. The survey was conducted in the digital design lab of the NC State University College of Textiles.

3.2.4 DATA ANALYSIS METHOD

The data analysis stage involved the preparation of the data for statistical analysis and the actual administration of the statistical tests. All evaluation tools were numbered prior to data collection to keep record of the total number of participants and assist in checking the accuracy of the data entering process. The evaluation tools were also labeled as having been evaluated by a non-expert or an expert. The data was entered, cleaned, and checked for accuracy. Next, the data was imported into the statistics program JMP for statistical testing.

Part one of the evaluation tool collected data used to describe the research participants' awareness of the techniques being evaluated. The distribution function of JMP was used to analyze this data. The distribution function provides a distribution of values with histograms, frequencies, and other graphical and textual reports.

The evaluation tool comprised fabric evaluation in two forms as described previously. Part two of the evaluation tool required the evaluators to rate the hand and digital samples individually. For the fabric samples rated individually, t-tests were performed using the JMP Oneway ANOVA test procedure to determine if there were significant differences between the digital and hand samples when evaluated on each of the defined qualities. The t-tests were performed for each aesthetic quality. The ANOVA procedure outputs a t-test table which provides the t-statistic and the probability of getting that t-statistic value if there is not a real difference between two means. A significance level of .05 was chosen to indicate a significant difference. The ANOVA procedure also results in a Means Table which gives the means and sample size for each of the factors.

The second evaluation section, part three, asked the evaluators to compare digital samples to hand standards based on the defined characteristics. The ratings of the experts and non-experts were first analyzed using the standard deviation and means. Also a t-test was performed using the JMP Oneway ANOVA test procedure to determine if there were significant differences between the expert and non-expert ratings of the digital samples when compared to the hand standards on each of the defined qualities. Data was analyzed separately for each aesthetic quality.

The last section of the evaluation tool asked the research sample to provide demographic information. The distribution function of JMP was used to analyze this data collected from the research sample.

For each printing technique, the qualities were tested separately. The data was analyzed for the entire sample and independently for non-experts and experts.

CHAPTER FOUR: RESEARCH RESULTS

Results of this research project are presented in two sections. The first section describes the methods and techniques for development of the digitally printed samples. The second section provides the findings from the evaluation process and includes the sample description and results from the data collection.

4.1 PART 1: CREATION OF DIGITAL SAMPLES

The following section addresses the research question "what methods and techniques can be used to achieve the aesthetic qualities of traditional batik and discharge using graphics programs and digital printing?" This section begins with the equipment and materials used in the creation of the digital batik and discharge fabric samples. Next, the common methods and techniques used to create both digital batik and discharge are discussed, and finally digital batik and digital discharge are discussed individually.

4.1.1 EQUIPMENT AND MATERIAL PARAMETERS

It was important to use fabrics similar to the standards to limit bias based on differences of fabric types. The fabric used for the batik standards was a high quality Egyptian cotton. The selection of pre-treated fabrics for digital printing was limited, so the Egyptian cotton was not available. Cotton percale and cotton sheeting were used in place of the Egyptian cotton. The cotton percale and sheeting did not exhibit the identical hand or luster as the standards, but was the best alternative available. Also, the fabric was special ordered un-backed so both sides of the fabric could be printed without skewing. The Stork Amber printer used for the digital printing allowed for only six inks all at medium concentration, limiting the range of printable colors.

4.1.2 PHOTOSHOP

PhotoShop was used to design both the digital batik and digital discharge fabrics. Certain program features proved especially valuable to the process. One important feature was PhotoShop's image layering capacity. Layering in a graphic image is like overlapping sheets of paper, except that the areas of a layer that contain no image are transparent. Each layer can be edited and altered independently of the others, including the viewing order. Also images on a layer can be edited and altered separately. The layering function of PhotoShop helped simulate the numerous layers of dying that occur in authentic batik printing. The layering function was also important in creating the discharge fabrics. Lightly colored images were overlaid on top of darker images and the opacity of the lightly colored image was adjusted to appear as if they had been discharged.

In PhotoShop, drawing and painting are done using brushes which are available in different shapes, sizes, pressures, and transparencies. Brushes are graphics tools which are meant to represent various paint brushes. PhotoShop has a feature that allows for alteration of existing brushes and creation of new brushes. This feature was important throughout the project for creating desired effects. In the batik fabrics, brushes were both created and altered to reproduce the liquid quality associated with batik lines and patterns. The creation of new brushes was essential to the success of the discharge prints. The motifs in the hand discharge samples were scanned into PhotoShop and made into new brushes. This allowed for the motifs on the digital samples to be similar to the motifs on the hand created samples. This was important to help minimize any bias associated with design qualities unrelated to the predefined aesthetic qualities.

4.1.3 DYED LOOK

A common characteristic of hand batik and discharge is that they are usually created through dying. When a fabric is dyed, it is submerged in a dyebath which saturates the entire fabric with color. In digital printing ink is applied to one side of the fabric. So, one challenge in the digital creation of these hand techniques was achieving the "dyed look."

One approach to crafting digitally printed fabric with a dyed appearance was to print on a thin substrate. If a substrate is relatively thin, and a sufficient amount of ink is laid down, the ink penetrates through both sides, leaving the fabric saturated with ink. After the fabric is steamed, it appears dyed. In order for the fabric to be saturated with ink, the amount of ink laid down has to be varied according to the substrate and fabric thickness. The ink penetration can be changed by altering the printing resolution or by changing the banding. Banding determines the number of passes a print-head makes over the fabric to print each area. Banding changes automatically when the resolution is changed, and it can also be changed manually.

Another approach to achieving a "dyed look" is to print both sides of the fabric. Digital printers are currently not set up to print both sides of the fabric simultaneously, so designing a method to print both sides required some experimentation. To print both sides, the fabric had to be printed, turned over, registered, and sent through the printer again. Registration is defined in the textile printing industry as "exact alignment of all rollers or screens in order to print all motifs onto the fabric in correct relation to one another" (Yates, 1996, p.166). Registration in this project meant matching the images on both sides of the fabric to each other. To register the image, registration lines were drawn onto the fabric and used as guidelines when the fabric was turned to print the underside. The fabric was cut into smaller pieces to make registration simpler.

Most fabrics treated for digital printing are paper backed to assist in feeding the fabric evenly through the printer. It was discovered that for printing both sides of the fabric it was better for the fabric not to be paper backed. In backed fabric, the paper must be removed prior to printing the under side. Removing the paper from the fabric often skewed it which made registration of the design difficult.

To insure the accuracy of the printing it was also important to keep the fabric on grain and under constant tension. Even so, it was not always possible to control the fabric and skewing could occur in the printing process. This remains a challenge for two sided printing.

Another important variable in printing both sides of the fabric was the banding or number of passes. The number of passes that could be used ranged from one to eight. For different fabric substrates and thicknesses the number of passes required had to be determined through experimentation. If too much ink was laid down, the ink would bleed over to the other side making the image blurred. If not enough ink penetrated the fabric, color appeared unsaturated. For the substrates used to print the digital batik and discharge four passes were used on each side of the fabric.

4.1.4 COLOR DATABASE

As previously mentioned fabric colors achieved through dying usually differ from those created through digital printing. Much time was invested in trying to match digital colors to those made through hand dying. The batik process involves over-dyeing. Over-dyeing is a process in which a single piece of fabric is dyed several times, using different colors. The colors resulting are a combination of the dyes used. To simulate this process in the digital colors, the layers in PhotoShop were used to overlay several colors on top of each other.

During the exploration it was found, that, even when printing the same color on different substrates the final colors following post-treatment were often different. To better control the final colors, printing substrates were limited to two. Also a color database was developed. Colors were numbered and saved in PhotoShop and then printed onto the fabric. The printed fabric colors were used as guides for all the colors used in the final fabric samples. A PhotoShop tool called the eyedropper was used to select colors from the database and then those colors were used in designing the digital batik and discharge samples. The advantage of having the color database was knowing what the final colors would look like on fabric after printing and post-treatment.

4.1.5 PRINTING LIGHT COLORS

During the development of the color database it was found that light colors didn't print as well as the medium to dark colors. The light colors printed with less quality because of a characteristic of ink jet printing called dithering. Dithering in an image is the visible appearance of the individual dots that make up the printed image. The Stork Amber printer uses six colors of the same concentration, so in the printed light colors the dithering was visible. To reduce the dithering of the light colors, three actions were performed. First the color database was used to select colors with minimal dithering. Second, saving the image on a transparent background as a PhotoShop Portable Document File (PDF) prevented dithering in any areas meant to be white. The dithering was prevented because the printer registered no color for the white areas, so no ink was placed onto the fabric. Lastly, the software program Pointcarrè was used to limit the number of colors in the digital batik and discharge designs. As previously mentioned dithering takes the colors available in the printer and creates additional colors by placing variable hues of the set colors next to each other. So, limiting the colors in the design allowed more control over the colors used in the dithering process.

4.1.6 PRINTING DARK COLORS

Black and other dark colors are difficult to achieve when dyeing and proved to be equally as difficult in digital printing. To achieve darker colors, the total ink limit was adjusted on the printer options. When the limit is set to less than 300%, more black dye and less Cyan, Magenta, and Yellow are used to create darker colors.

4.1.7 BATIK

All of the previous techniques discussed were used in designing the batik fabric samples. In addition to these techniques a technique was developed to achieve the batik characteristic, cracking. Cracking proved to be the most difficult quality of batik to create through graphics programs and digital printing. The cracking effect is random in nature; therefore, it is difficult to create intentionally. Also, the lines created from cracking are very fine which was also a challenge to achieve in the digitally printed images.

Several approaches were explored to create the cracking effect. The first was sketching the cracks by hand in PhotoShop. This method was somewhat effective in line quality, but was very time consuming. The second method was to scan batiked fabrics, select the cracks, and cut and paste them throughout the image. The cracks created from the fabric scans were generated more quickly, but weren't as fine in quality as the hand batik fabrics. The optimal method was to scan batiked paper. The paper was chosen because the surface texture allowed for better resolution than the fabric scans. Also the batiked paper only consisted of two colors which made the selection of the cracks simpler.

Once the cracks were scanned a database was built of all the cracks. The cracks were then placed into the batik design in one of two ways. The first was by simply cutting and pasting the cracks into the image. Some editing and clean up was done to make the cracks fit into the appropriate areas. Cutting and pasting the cracks into the images was still time consuming, so an improved method was developed. This method involved creating cracking patterns. Patterns are elements repeated over several times in a repeating composition (Jerstorp & Kohlmark, 1988). PhotoShop has a feature that takes a defined image and creates a repeating pattern from it. Several crack images were placed together and defined as a pattern. The pattern was then filled into the batik image. Additional editing and clean up was done on the image to increase variation making the cracks look authentic. This method was the most successful in achieving the cracking effect. Figures 17, 18, 19, and 20 on the following pages show the digital batik fabrics A, B, C, and D.

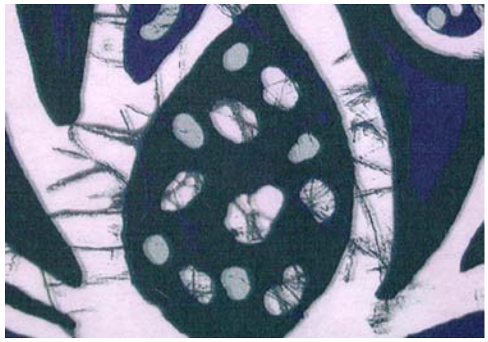


Figure 17: Digital Batik A

Figure 18: Digital Batik B

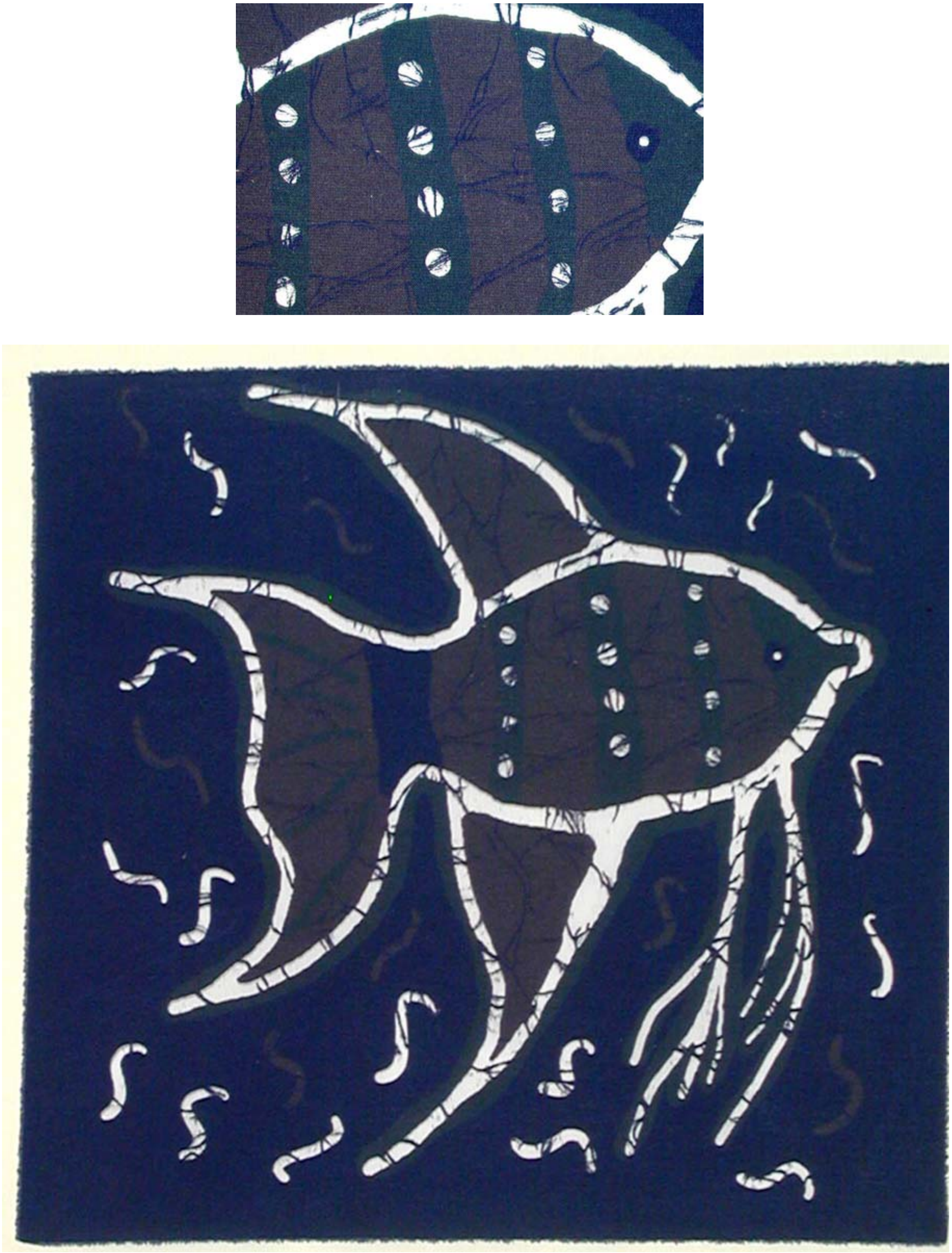


Figure 19: Digital Batik C

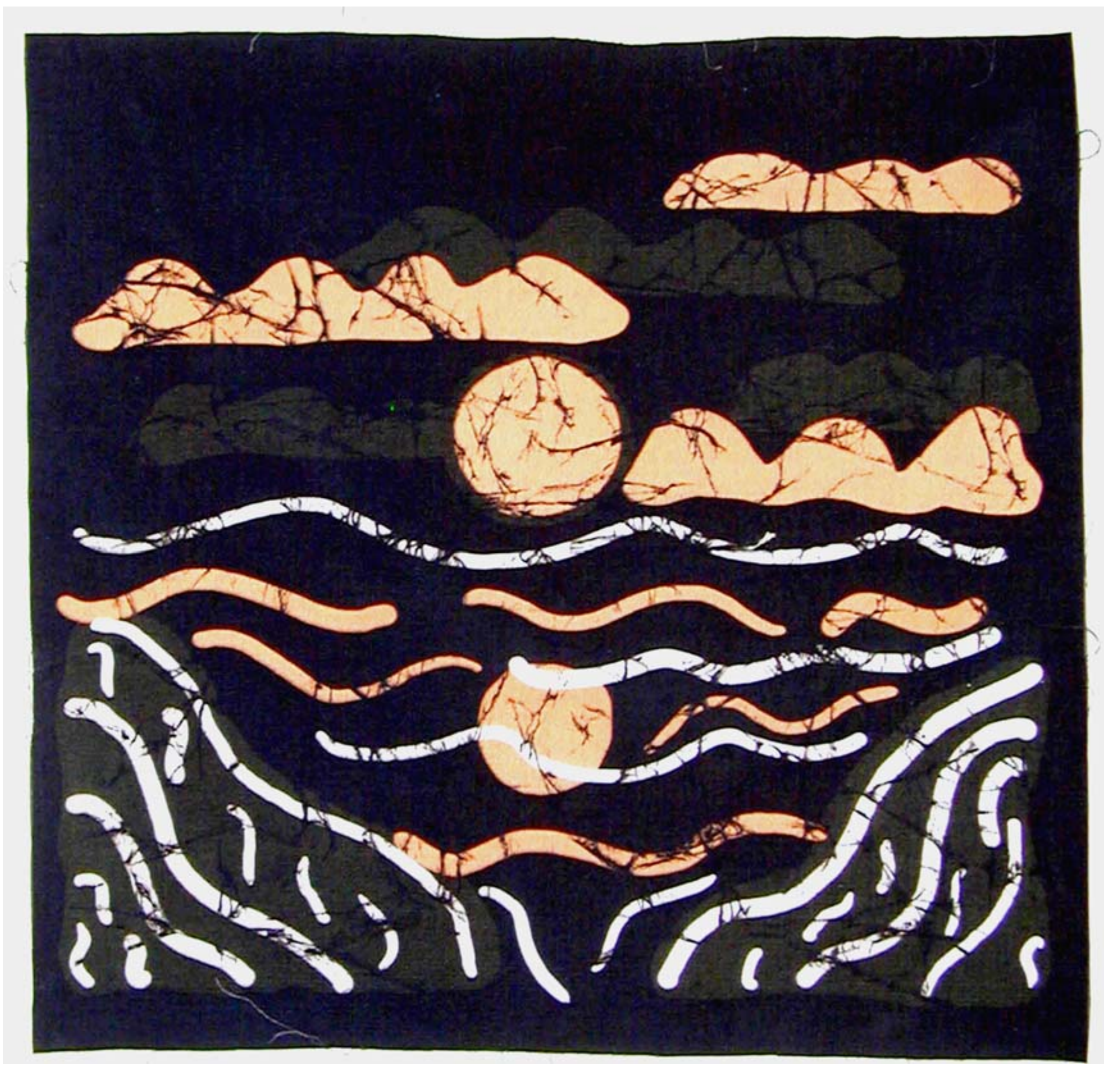


Figure 20: Digital Batik D

4.1.8 DISCHARGE

All previous methods discussed were used in designing the discharge fabric samples. An additional technique was created to achieve the discharge characteristics of color stained patterns and variety in removal of color. Discharge printing produces design motifs with varying amounts of color removal, and this variation continues throughout the entire pattern. In hand crafted discharge prints the appearance of this effect is random. Attempts to create random variation in color solely through graphic program tools proved unsuccessful. Alternative strategies were devised to bring randomly colored images into graphics programs. Images were brought into PhotoShop through two methods. Randomly colored images where downloaded from the web and manipulated, and water colored papers were scanned into PhotoShop. Once the images were in PhotoShop, the colors were changed and blended to achieve a dyed look. The blended images provided the color basis for the patterns that were used for the discharge prints. The following Figures 21, 22, 23, and 24 show the digitally created discharge fabrics A, B, C, and D.

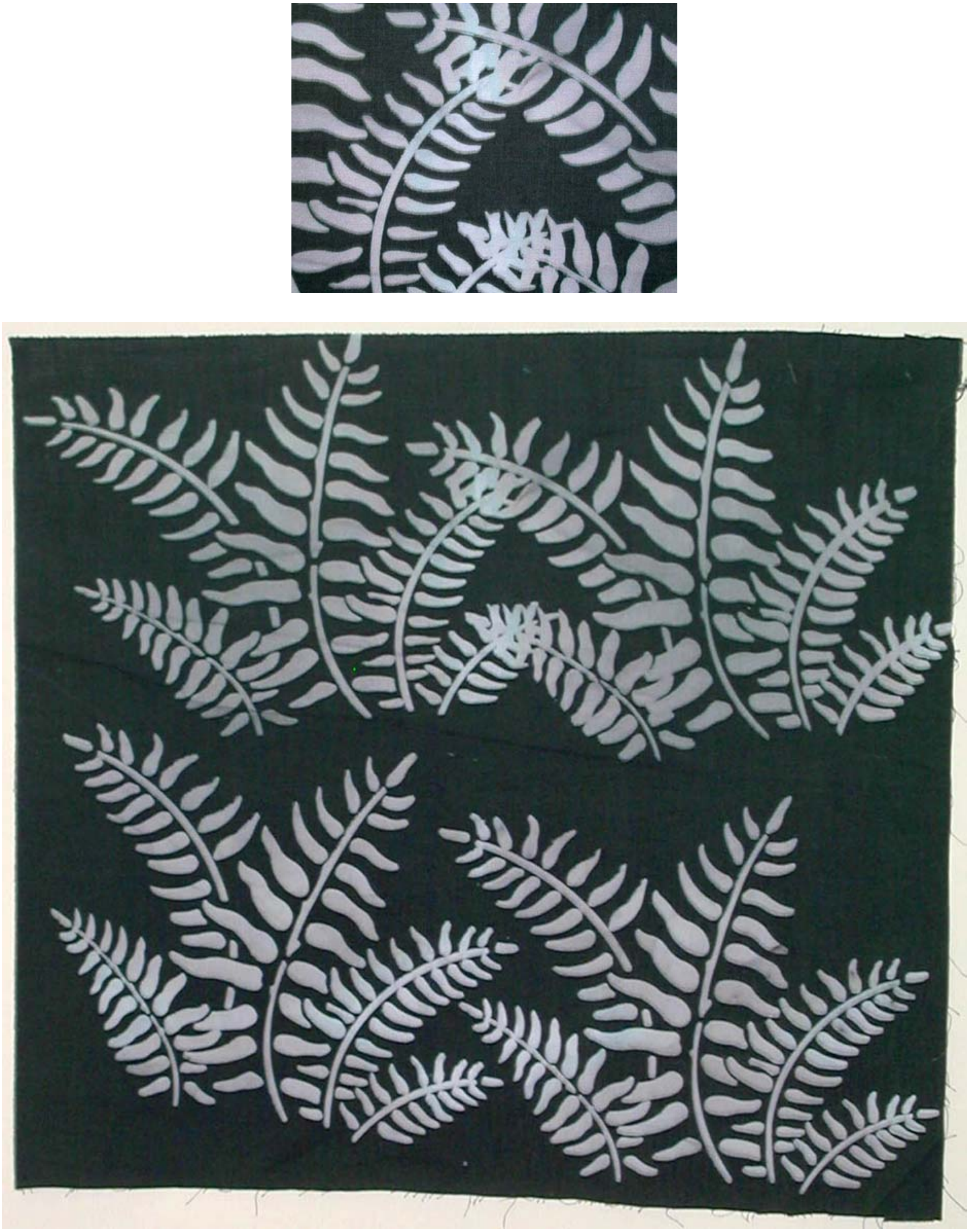


Figure 21: Digital Discharge A

Figure 22: Digital Discharge B

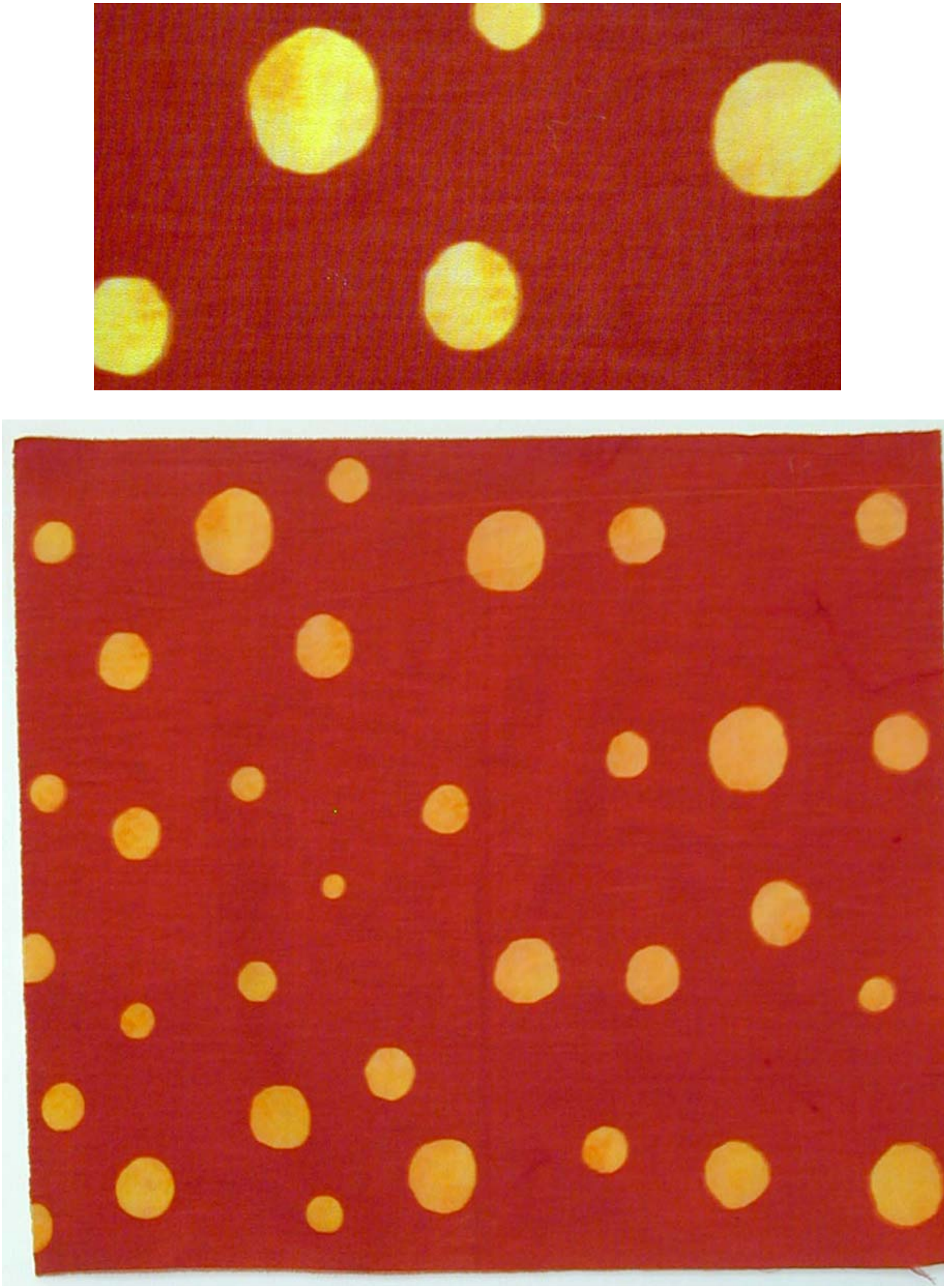


Figure 23: Digital Discharge C

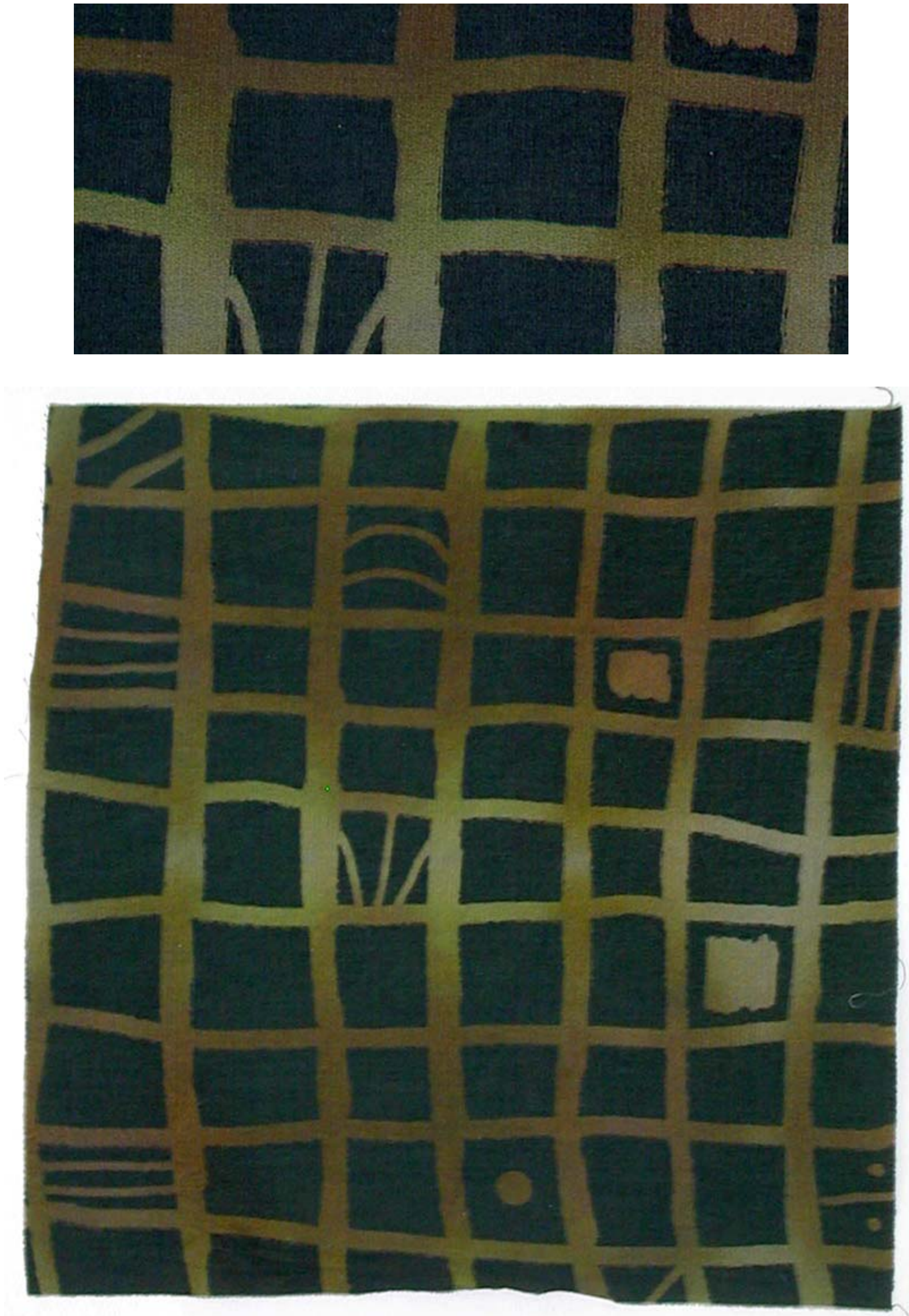


Figure 24: Digital Discharge D

4.2 PART 2: EVALUATION RESULTS

4.2.1 DESCRIPTION OF SAMPLE

There were a total of 40 research participants; half were non-experts and half were experts. As identified earlier in the research methodology, section two, research participants were classified as expert or non-expert according to specified qualifications before they partook in the evaluation process. The following sections describe the research sample broken down according to expertise of the participant. Information from part one of the evaluation tool is used to further characterize the research sample.

4.2.2 NON-EXPERT SAMPLE DESCRIPTION

4.2.2.1 NON-EXPERT DEMOGRAPHIC RESULTS

The non-expert sample separated by gender is illustrated in Figure 25. As can be seen, the sample was predominately female. There were a total of 20 non-experts and 18 of them were women.

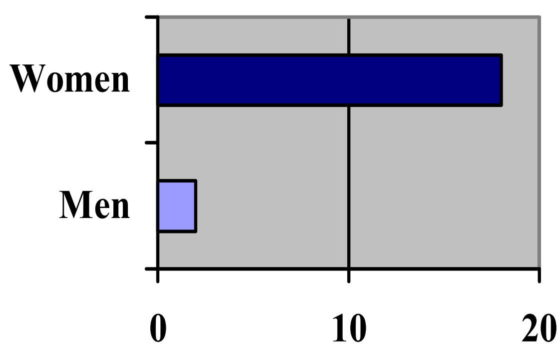


Figure 25: Non-Expert Sample by Gender

The non-expert sample separated by age is illustrated in Figure 26. Six of the non-experts were between the ages of 45-54, 5 were between the ages of 18-24, 5 were between the ages of 25-34, 3 were between the ages of 35-44, and 1 was between the ages of 55-64.

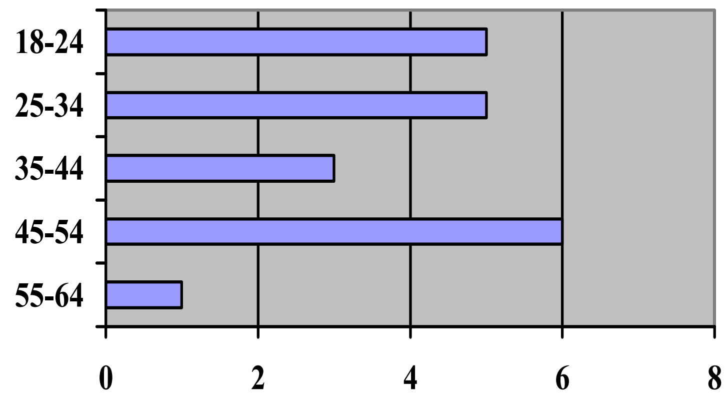


Figure 26: Non-Expert Sample by Age

The non-expert sample separated according to type of employment is illustrated in Figure 27. The majority of the non-expert participants were in administrative jobs.

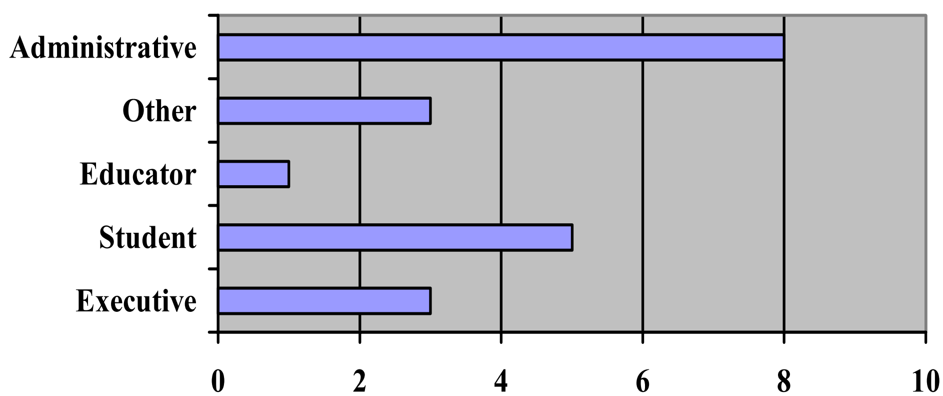


Figure 27:Non-Expert Sample by Employment

Out of the 20 non-expert evaluators 8 were in administrative positions, 5 were students, 3 were executives, 3 were classified as other, and only 1 was an educator.

4.2.2.2 NON-EXPERT FAMILARITY AND OPINION OF BATIK AND DISCHARGE

The non-experts familiar with the batik techniques totaled 7. These subjects responded as follows to the importance of each aesthetic quality to the batik look;

- 7 out of 7 identified cracking or veining
- 7 our of 7 identified waxy lines and patterns
- 3 out of 7 identified halos around images
- 5 out of 7 identified saturation of color
- 4 out of 7 identified image on both sides of the fabric

The non-expert subjects familiar with discharge totaled 4. These subjects responded as follows to the importance of each aesthetic quality to the discharge look;

- 4 out of 4 identified dark backgrounds with light figures
- 3 out of 4 identified distinct pattern edges
- 3 out of 4 identified removal of color leaving color stained patterns
- 2 out of 4 identified saturation of color
- 4 out of 4 identified variety of color removal
- 4 identified removal of color from both sides of the fabric

4.2.3 EXPERT SAMPLE DESCRIPTION

4.2.3.1 EXPERT DEMOGRAPHIC RESULTS

Following are the results describing the expert research sample. Figure 28 provides a visual description of participants in the expert sample according to sex. As shown in Figure 20 the sample consisted predominately of females. Ninety-five percent of the expert participants were female meaning there was only one male expert in the sample.

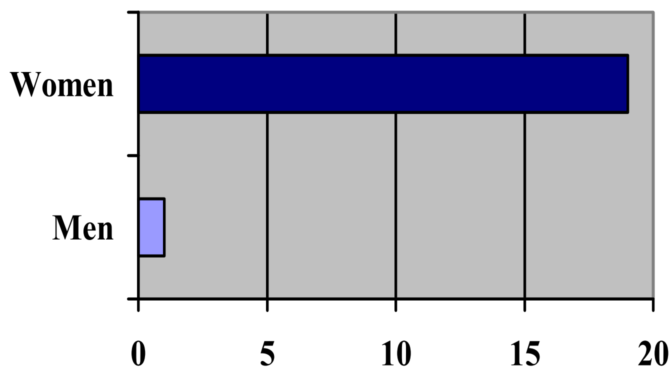


Figure 28: Expert Sample by Gender

The visual representation of the expert sample separated by age is shown in Figure 29. The largest numbers of participants were between the ages of 35-54. Of the 20 expert evaluators, 7 were between the ages of 45-54, 6 were between the ages of 35-44, 3 were between the ages of 25-34, 2 were between the ages of 18-24, and 2 were between the ages of 55-64. There were no expert participants below the age of 18 or above the age of 64.

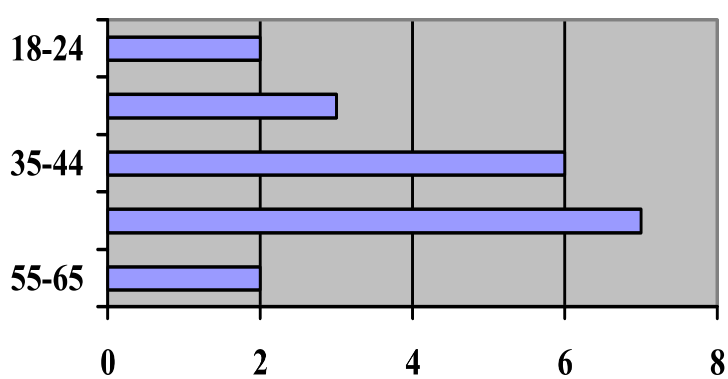


Figure 29: Expert Sample by Age

Figure 30 provides a visual representation of the employment of the expert sample. A majority of the experts were professional artists. The second largest group was students.

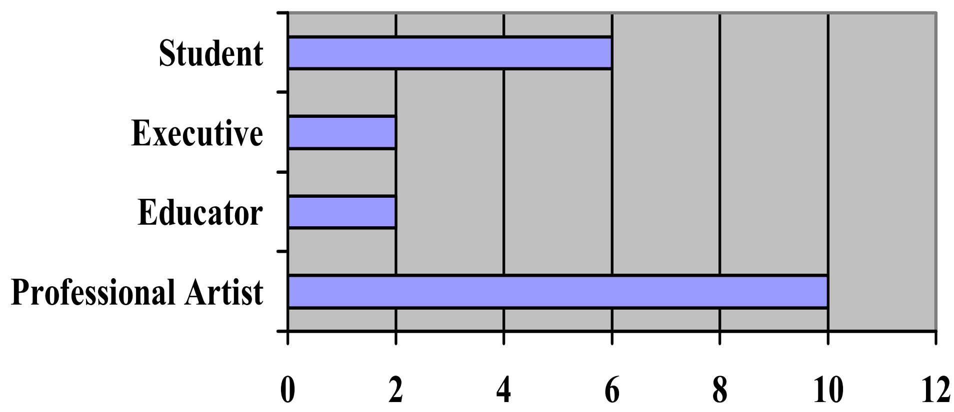


Figure 30: Expert Sample by Employment

Out of the 20 evaluators 10 were professional artists, 6 were students, 2 were educators, and 2 were executives.

4.2.3.2 EXPERT FAMILIARITY AND OPINION OF DISCHARGE AND BATIK

All 20 experts were familiar with both discharge and batik printing methods. Following are the expert opinions of the aesthetic qualities important to the batik look;

- 19 out of 20 identified cracking or veining
- 17 out of 20 identified waxy lines and patterns
- 9 out of 20 identified halos around images
- 14 out of 20 identified saturation of color
- 13 out of 20 identified image on both sides of the fabric

Following are the expert opinions of the aesthetic qualities important to the discharge look;

- 19 out of 20 identified dark background with light figures
- 13 out of 20 identified distinct pattern edges
- 18 out of 20 identified removal of color leaving color stained patterns
- 9 out of 20 identified saturation of color

- 18 out of 20 identified variety of color removal
- 7 out of 20 identified removal of color from both sides of the fabric

4.2.4 DATA ANALYSIS

The non-expert and expert subjects described in the previous section provided the data for the following analysis. To answer the research question, "how well do samples of batik and discharge created with graphics programs and digital printing represent the aesthetic qualities associated with traditional batik and discharge?", aesthetic qualities were evaluated separately for both batik and discharge. The t-test statistic generated by the JMP Oneway ANOVA procedure was used to determine significant differences between digital and hand ratings and expert and non-expert responses. The results of the data analysis are presented according to the predefined aesthetic qualities.

4.2.4.1 BATIK ANALYSIS

The following hypotheses were developed for statistical testing of the batik data.

<u>Hypothesis One</u>: There is no significant difference between the aesthetic qualities of handcrafted batik and aesthetic qualities of digitally generated and digitally printed batik.

<u>Hypothesis Two</u>: There is no significant difference between the aesthetic qualities of handcrafted batik and aesthetic qualities of digitally generated and digitally printed batik when viewed by a non-expert.

<u>Hypothesis Three</u>: There is no significant difference between the aesthetic qualities of handcrafted batik and aesthetic qualities of digitally generated and digitally printed batik when viewed by an expert.

For all batik aesthetic qualities results are provided separately for the entire research sample, non-experts, and experts. The combined analysis results address hypothesis one, the non-expert analysis results address hypothesis two, and the expert analysis results address hypothesis three.

The first set of results were derived from Part 2 of the evaluation tool where digital and hand samples were evaluated independently. The evaluators were not privy to the methods used to create each fabric sample. The directions were as follows; “You are to evaluate four fabric samples by filling out the following four forms. Rate the aesthetic appeal of each fabric sample according to the characteristics listed.” Recall that all fabric samples were evaluated on a scale of 1 to 5, where 5 represented the highest and 1 represented the lowest. T-tests were performed using the JMP Oneway ANOVA procedure for each aesthetic quality of batik. A probability of .05 was selected to determine significant differences. For each quality the data is organized by the group that performed the analysis and by the method used to create the samples. Combined refers to results for the entire sample combining the non-expert and expert data.

4.2.4.1.1 RESULTS FROM PART TWO OF BATIK EVALUATION TOOL

The first batik aesthetic quality evaluated was “cracking or veining”, which occurs when the cooled batik wax has cracked, and dye penetrates the small cracks creating the effect. Table 2 presents the results from the t-test on cracking and veining. The combined data results show a significant difference between means for the digital and hand samples. The non-expert group results show no significant difference between

Table 2: Batik Analysis of Cracking or Veining Oneway ANOVA Testing Results					
Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	4.3	-3.8	.0002
	Digital	80	3.7		
Non-expert	Hand	40	4.2	-.5	.62
	Digital	40	4.1		
Expert	Hand	40	4.4	-5.97	.0001
	Digital	40	3.4		

the hand and digital mean ratings. The expert group results show a significant difference between the digital and hand mean ratings.

The next characteristic evaluated was batik's "waxy lines and patterns". Batik lines and patterns are created using hot, liquid wax so they have a flowing liquid quality. Table 3 illustrates the results from the t-test on waxy lines and patterns. The combined

Table 3: Batik Analysis of Waxy Lines/Patterns Oneway ANOVA Testing Results					
Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	4.4	-3.67	.0003
	Digital	80	3.8		
Non-expert	Hand	40	4.2	-.65	.521
	Digital	40	4.1		
Expert	Hand	40	4.5	-4.68	.0001
	Digital	40	3.6		

data results show a significant difference between means for the digital and hand samples. When analyzed independently, the non-expert group results show no significant difference between the means. The expert group results show a significant difference between the hand and digital mean ratings.

The next quality evaluated was the appearance of “halos around images”. Halos are darker or lighter outlines created around images which can be caused from over dyeing or left over wax. Table 4 illustrates the results from the t-test on appearance of halos around images. The combined data results returned a significant difference between the digital and hand samples. The non-expert data results show no significant

Table 4: Batik Analysis of Halos Around Images Oneway ANOVA Testing Results

Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	3.7	-2.36	.019
	Digital	80	3.3		
Non-expert	Hand	40	3.8	0	1
	Digital	40	3.8		
Expert	Hand	40	3.6	-3.97	.0002
	Digital	40	2.8		

difference between the means. The expert results show a significant difference.

The next batik quality evaluated was “saturation of color.” Since batik designs are created through dyeing the fabric is usually wet through with color. Table 5 illustrates the results of the t-test on saturation of color. The combined group results show no significant difference between the hand and digital means. The non-expert

Table 5: Batik Analysis of Saturation of Color Oneway ANOVA Testing Results

Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	4.3	-1.67	.097
	Digital	80	4.1		
Non-expert	Hand	40	4.3	-.85	.397
	Digital	40	4.2		
Expert	Hand	40	4.3	-1.51	.133
	Digital	40	4.0		

group results also show no significant differences. The expert group results show no significant differences between the digital and hand samples in saturation of color.

The last batik characteristic evaluated was the "appearance of the image on both sides of the fabric." In traditional batik, wax is applied to both sides of the fabric, so when the fabric is dyed the image is created on both sides of the digital samples. Table 6 presents the results from the t-test on appearance of the image on both sides of the fabric. The combined data results show no significant difference between the hand

Table 6: Batik Analysis of Appearance of Image on Both Sides Oneway ANOVA Testing Results

Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	4.6	-0.24	0.809
	Digital	80	4.5		
Non-expert	Hand	40	4.5	0.47	0.64
	Digital	40	4.5		
Expert	Hand	40	4.7	-0.96	0.342
	Digital	40	4.6		

and digital mean ratings. The non-expert results show no significant difference between the means. The expert results also show no significant difference between the digital and hand means for appearance of image on both sides of the fabric.

4.2.4.1.2 SUMMARY

Hypothesis one was rejected for batik aesthetic qualities cracking or veining, waxy lines and patterns, and halos around images due to significant differences found between the handcrafted and digital samples. Hypothesis two was accepted for all of the batik aesthetic qualities. Hypothesis three was rejected for batik aesthetic qualities cracking or veining, waxy lines and patterns, and halos around images.

4.2.4.1.3 RESULTS FROM PART THREE OF BATIK EVALUATION TOOL

The next section reports results from Part 3 of the survey where evaluators rated digitally designed and printed batik samples against "standards" created by hand. The instructions were as follows; "Examine the two Batik Standards to gain an understanding of how the standards demonstrate the characteristics of batik. Next examine the numbered samples and evaluate how well they demonstrate the batik characteristics in comparison to the Batik Standards." Recall that when evaluated against the hand standards, the digital samples were rated on a scale of 1 to 5, where 5 represented "as well as the standard" and 1 represented "not at all". Standard deviations and means were generated for each batik aesthetic characteristic. Then, t-test statistic was used to determine if there was a significant difference between expert and non-expert ratings on each quality. Combined refers to results for the entire sample combining the non-expert and expert results.

Digital samples were first evaluated on the "cracking or veining" quality described previously Table 7 illustrates the results from the evaluation of digital cracking or veining when compared to the hand standards. Note the asterisk shows that there is a significant difference in how non-experts and expert rated the digital cracking or veining in comparison to the hand standard.

Table 7: Batik Analysis of Digital Cracking or Veining to Standard

Analysis	SD	Mean	t-test	Prob > |t|
Combined	1.1	3.8	-5.92	<.0001
Non-expert	0.9	4.4*		
Expert	0.9	3.2*		

The next batik quality evaluated was, "waxy lines and patterns", which was previously described. Table 8 illustrates the analysis of digital waxy lines and patterns when compared to hand standards. Note the asterisk shows that there is a significant difference between the non-expert and expert ratings of the digital waxy lines and patterns in comparison to the hand standard.

Table 8: Batik Analysis of Digital Waxy Lines/Patterns to Standard

Analysis	SD	Mean	t-test	Prob > |t|
Combined	1	4	3.5	0.0009
Non-expert	0.9	4.3*		
Expert	1	3.6*		

The next batik quality evaluated was appearance of "halos around images" which was previously described. Table 9 illustrates the data analysis of digital halos around images when compared to hand standards. Note the asterisk shows that there is a significant difference between the non-expert and expert evaluations of the digital samples when compared to hand standards.

Table 9: Batik Analysis of Digital Halos Around Images to Standard

Analysis	SD	Mean	t-test	Prob > |t|
Combined	0.9	3.9	-5.7	<.0001
Non-expert	0.8	4.4*		
Expert	0.8	3.4*		

Next, the digital samples were then evaluated on the quality, "saturation of color" which was previously described. Table 10 illustrates results of the data analysis of digital saturation of color when compared to hand standards. Notice there is no significant difference between the non-expert and expert ratings of saturation of color.

Table 10: Batik Analysis of Digital Saturation of Color to Standard

Analysis	SD	Mean	t-test	Prob > |t|
Combined	0.7	4.4	-0.99	0.323
Non-expert	0.7	4.5		
Expert	0.9	4.3		

The last batik quality evaluated was appearance of the "image on both sides of the fabric", which was previously described. Table 11 presents the analysis results for the digital appearance of the image on both sides of the digital fabrics samples when compared to hand standards. Notice there is no significant difference between the non-expert and expert ratings of the digital appearance of the image on both sides of the fabric.

Table 11: Batik Analysis of Digital Appearance of Image on Both Sides to Standard

Analysis	SD	Mean	t-test	Prob > |t|
Combined	0.7	4.6	-0.17	0.87
Non-expert	0.6	4.6		
Expert	0.7	4.6		

4.2.4.2 DISCHARGE ANALYSIS

The following hypotheses were developed for statistical testing of the discharge data.

Hypothesis Four: There is no significant difference between the aesthetic qualities of handcrafted discharge and aesthetic qualities of digitally generated and digitally printed batik.

Hypothesis Five: There is no significant difference between the aesthetic qualities of handcrafted discharge and aesthetic qualities of digitally generated and digitally printed batik when viewed by a non-expert.

Hypothesis Six: There is no significant difference between the aesthetic qualities of handcrafted discharge and aesthetic qualities of digitally generated and digitally printed batik when viewed by an expert.

For all discharge aesthetic qualities results are provided separately for the entire research sample, non-experts, and experts. The combined analysis results address hypothesis four, the non-expert analysis results address hypothesis five, and the expert analysis results address hypothesis six.

The first set of results were derived from Part 2 of the discharge evaluation tool where digital and hand samples were evaluated independently. The evaluators were not privy to the methods used to create each fabric sample. The directions were as follows; "You are to evaluate four fabric samples by filling out the following four forms. Rate the aesthetic appeal of each fabric sample according to the characteristics listed." Recall that all fabric samples were evaluated on a scale of 1 to 5, where 5 represented the highest and 1 represented the lowest. T-tests were performed using the JMP Oneway ANOVA procedure for each aesthetic quality of batik. A probability of .05 was selected to determine significant differences. For each quality the data is organized by the group that performed the analysis and by the method used to create the samples. Combined refers to results for the entire sample combining the non-expert and expert data.

4.2.4.2.1 RESULTS FROM PART TWO OF DISCHARGE EVALUATION TOOL

The first discharge aesthetic quality evaluated was "dark backgrounds with light patterns." Discharge is the removal of color from fabric, so it is often used to achieve light patterns on fabric while maintaining a dark background. Table 12 illustrates the results from the t-test on dark background with light patterns. The combined data results show no significant difference between the digital and hand sample means. The

Table 12: Discharge Analysis of Dark Background with Light Patterns Oneway ANOVA Testing Results

Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	4.1	1.51	0.134
	Digital	80	4.3		
Non-expert	Hand	40	3.8	2.47	0.016
	Digital	40	4.4		
Expert	Hand	40	4.4	-0.77	0.4
	Digital	40	4.3		

non-expert group results show a significant difference between the hand and digital samples. The expert group results show no significant difference between the digital and hand samples for the discharge characteristic dark background with light patterns.

The next discharge quality evaluated was "distinct pattern edges." Because discharge uses a paste to remove color from a pre-dyed fabric the edges of the pattern are usually crisp and distinct. Table 13 presents the results from the t-test on distinct pattern edges. The combined data results show no significant difference between the digital and hand mean ratings. The non-expert results show a significant difference

Table 13: Discharge Analysis of Distinct Pattern Edges Oneway ANOVA Testing Results

Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	3.9	1.23	0.221
	Digital	80	4.2		
Non-expert	Hand	40	3.7	2.05	0.043
	Digital	40	4.3		
Expert	Hand	40	4.2	-0.58	0.6
	Digital	40	4.0		

between the hand and digital samples. The expert data results show no significant difference between the digital and hand samples.

The next discharge aesthetic quality evaluated was "removal of color leaving colored stained patterns." Discharge usually does not remove color evenly, so often the patterns are partially white or appear stained. Table 14 illustrates the results from the t-test on removal of color leaving color stained patterns. The combined data results show no significant difference between the hand and digital samples. The non-expert results

Table 14: Discharge Analysis of Removal of Color Leaving Color Stained Patterns Oneway ANOVA Testing Results

Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	3.9	0.08	0.94
	Digital	80	3.9		
Non-expert	Hand	40	3.7	1.81	0.074
	Digital	40	4.1		
Expert	Hand	40	4.1	-2.3	0.024
	Digital	40	3.7		

show no significant difference between the digital and hand samples. The expert results show a significant difference between the digital and hand samples.

The next discharge quality evaluated was "saturation of color." Discharge is commonly performed on dyed fabric, so the fabric is usually wet through with color. Table 15 presents the results from the t-test for saturation of color. The combined data results show no significant difference between the digital and hand sample for the saturation of color. The non-expert data results show no significant difference between the hand and digital mean ratings. The expert results also show no significant

Table 15: Discharge Analysis of Saturation of Color Oneway ANOVA Testing Results

Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	4.1	0.83	0.407
	Digital	80	4.2		
Non-expert	Hand	40	3.8	1.68	0.098
	Digital	40	4.2		
Expert	Hand	40	4.3	-0.84	0.4
	Digital	40	4.2		

difference between the digital and hand samples.

The discharge quality "variety of color removal" was the next aesthetic quality to be evaluated. Because discharge is not consistent in its removal of color, the overall design may consist of white patterns along with stained patterns. Table 16 presents the results from the t-test on variety of color removal. The combined data results show no significant difference

Table 16: Discharge Analysis of Variety of Color Removal Oneway ANOVA Testing Results

Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	3.9	-0.08	0.94
	Digital	80	3.9		
Non-expert	Hand	40	3.8	1.05	0.298
	Digital	40	4.1		
Expert	Hand	40	3.9	-1.49	0.1
	Digital	40	3.6		

between the digital and hand samples means. The non-expert results show no significant difference between the digital and hand mean ratings. The expert data results also show no significant difference between the digital and hand mean ratings.

The last quality evaluated was the "removal of color from both sides of the fabric." The discharge paste often penetrates through the fabric removing color on both sides of the fabric. Table 16 illustrates the results from the t-test on removal of color from both sides of the fabric. The combined data results show no significant difference between the digital and hand sample mean rating. The non-expert results show no significant

Table 17: Discharge Analysis of Removal of Color from Both Sides Oneway ANOVA Testing Results

Analysis	Method	Number	Mean	t-test	Prob > |t|
Combined	Hand	80	4.4	-0.2	0.846
	Digital	80	4.3		
Non-expert	Hand	40	4.2	0.51	0.611
	Digital	40	4.3		
Expert	Hand	40	4.5	-0.9	0.4
	Digital	40	4.4		

difference between the hand and digital samples. The expert data results also show no significant difference between the digital and hand sample mean ratings.

4.2.4.2.2 SUMMARY

Hypothesis four was accepted for all of the discharge aesthetic qualities. Hypothesis five rejected for the discharge qualities dark backgrounds with light patterns and distinct pattern edges due to significant differences between the handcrafted and digital fabric samples. Hypothesis six was rejected for the discharge aesthetic quality removal of color leaving color stained patterns.

4.2.4.2.3 RESULTS FROM PART THREE OF DISCHARGE EVALUATION TOOL

The next section reports results from Part 3 of the discharge evaluation tool. In Part 3 subjects rated digitally designed and printed samples against "standards" created by hand. The instructions for the discharge evaluation were the same as the batik. The discharge digital samples were rated on a scale of 1 to 5, where 5 represented "as well as the standard" and 1 represented "not at all". Standard deviations and means were generated for each discharge aesthetic characteristic. Then the t-test statistic was used to determine if there was significant difference between the expert and non-expert ratings on each quality. Combined refers to results of the entire sample combining the non-expert and expert data.

The digital samples were first compared to the hand standards for the discharge quality "dark backgrounds with light patterns," which was previously explained. Table 17 presents the results from the evaluation of digital dark background with light patterns when compared to hand standards. It is important to note there is no significant difference between the non-expert and expert evaluation of this aesthetic quality.

Table 17: Discharge Analysis of Digital Dark Background with Light Patterns to Standard

Analysis	SD	Mean	t-test	Prob > |t|
Combined	0.9	4.2	-0.38	0.71
Non-expert	0.9	4.3		
Expert	0.9	4.2		

The next quality evaluated was "distinct pattern edges," which was previously described. Table 18 illustrates the results from the evaluation of digital distinct pattern edges. Note that the asterisk shows there is a significant difference between the non-expert and expert ratings for the distinct pattern edges quality.

Table 18: Discharge Analysis of Digital Distinct Pattern Edges to Standard

Analysis	SD	Mean	t-test	Prob > |t|
Combined	1.1	3.6	-2.4	0.018
Non-expert	1.1	3.9*		
Expert	1	3.3*		

The next discharge aesthetic quality evaluated was "removal of color leaving color stained patterns," which was previously explained. Table 19 presents the results from the evaluation of digital removal of color leaving color stained patterns. Note that the asterisk shows there is a significant difference between the non-expert and expert evaluation of the digital samples when compared to hand standards.

Table 19: Discharge Analysis of Digital Removal of Color Leaving Color Stained Patterns to Standard

Analysis	SD	Mean	t-test	Prob > |t|
Combined	1	4	-2.7	0.01
Non-expert	1	4.3*		
Expert	0.9	3.8*		

Next the "saturation of color" quality was evaluated for the digital samples. Table 20 illustrates the results from the evaluation of digital saturation of color when compared to hand standards. There is no significant difference between the non-expert and expert evaluations. The mean rating for saturation of color was 4.2 for both expert and non-experts.

Table 20: Discharge Analysis of Digital Saturation of Color to Standard

Analysis	SD	Mean	t-test	Prob > |t|
Combined	1	4.2	-0.11	0.915
Non-expert	1.1	4.2		
Expert	1	4.2		

The next discharge aesthetic quality evaluated was "variety of color removal," which was previously described. Table 21 illustrates the results from the evaluation of digital variety of color removal when it was compared to hand standards. Note that the asterisk shows there is a significant difference between the non-expert and expert evaluation of digital variety of color removal.

Table 21: Discharge Analysis of Digital Variety of Color Removal to Standard				
Analysis	SD	Mean	t-test	Prob > |t|
Combined	1	4.1	-2.44	0.017
Non-expert	1.1	4.2*		
Expert	0.9	3.8*		

The last discharge quality evaluated was the "removal of color from both sides of the fabric," which was previously described. Table 22 presents the results from the evaluation of digital removal of color from both sides of the fabric. Notice that there is no significant difference between the non-expert and expert evaluation of the digital samples compared to hand standards. The non-expert group and expert group both gave the digital removal of color from both sides of the fabric a mean rating of 4.5.

Table 22: Discharge Analysis of Digital Removal of Color from Both Sides to Standard				
Analysis	SD	Mean	t-test	Prob > |t|
Combined	0.8	4.5	0	1
Non-expert	0.9	4.5		
Expert	0.7	4.5		

CHAPTER FIVE: DISCUSSION

This research project explored how handcrafted batik and discharge aesthetic qualities could be created through graphics programs and digital printing technology. The traditional hand processes were studied in depth and aesthetic qualities were established and defined for both batik and discharge. The objective of this research was to determine if the aesthetic qualities associated with the traditional hand surface design techniques of batik and discharge could be achieved using graphics programs and digital printing technology. The objective was broken down into two research questions. The first research question was "what methods and techniques can be used to achieve the aesthetic qualities of traditional batik and discharge using graphic programs and digital printing?" It was addressed through the development of digital batik and discharge fabrics. Through the development of digital batik and discharge samples, methods and techniques were established to create the aesthetic qualities associated with traditional batik and discharge. These methods and techniques were documented in part one of the research results. The second was "how well do samples of batik and discharge created with graphics programs and digital printing represent the aesthetic qualities associated with traditional batik and discharge?" It was addressed through evaluation of digital batik and discharge samples. An evaluation tool was designed for use in evaluating batik and discharge fabrics according to their aesthetic qualities. Hypotheses were formulated and statistical tests of the hypotheses were conducted to discover how well the digital samples represented the identified aesthetic qualities.

5.1 DIGITAL SAMPLES

A total of 4 batiks and 4 discharge samples were created for this research. The successes of the final samples were limited by available digital technology. As digital printing technology advances, the methods and techniques presented here could be applied to creation of even better samples.

A major issue that could be eliminated with specialized technology was the visible dithering that occurred in the light colors and made the batik cracks less authentic in appearance. If access to a printer with a wider range of colors, at differing concentrations, was available this problem would have been avoided. Currently there are printers on the market that have up to twelve print-heads with varying ink concentrations. The increased color range could lessen and even eliminate the dithering effect. Other printer issues were general machine problems such as banding and color variation within the samples. Banding is the presence of visible horizontal lines in a printed image caused by insufficient color or gray-scale ranges within the printer's image processor, or insufficient information contained within the original image (Rienert, 2002). It is seen most in printed areas that fade from light to dark. Banding in the digital samples detracted from the "dyed look" and allowed for a visible difference between the digital and hand samples. Finally, development of printers designed to print both sides of the fabric would be beneficial and improve the batik and discharge designs. This would require accompanying development of fabrics prepared to print on both sides simultaneously.

The second technology area that could be improved for the methods and techniques developed here was the graphics software. Adobe PhotoShop was the central graphics program used. This program is extensive and powerful, but could be improved from the surface designer's perspective. Graphic images are created with pixels, which are tiny (square) elements that, when put together, make up a complete image. When pixels don't transition smoothly, each individual square remains apparent and images are said to look pixilated. It was impossible to conceal the pixilation of the brush lines on the outer edges, making rounded liquid lines difficult to create. Batik lines require smooth, curved edges and the pixilation took away from the line quality. It would be beneficial to have brushes and filters designed specifically to simulate some qualities of surface design such as batik waxy lines and varied removal of color. If graphic program designers took into consideration the aesthetic qualities surfaced designers require, they could design brushes with the quality of batik lines along with brushes for other techniques. Filters are special effects generated in graphics programs. They are applied to images to modify them in some way, such as blurring or smearing. A batik cracking filter could benefit the appearance of the cracking effect in the digital batik samples. Regardless of the improvements which could be made through access to advanced technology, the digital batik and discharge fabrics were very successful as is demonstrated in the fabric evaluations.

5.2 DIGITAL SAMPLE EVALUATION

Digital batik and discharge samples were completed and evaluated by non-experts and experts. The non-experts and experts rated the digital samples differently, but both groups rated them positively. The methods and techniques used to create the digital batik and discharge were successful. The following discussion characterizes the level of success of each digital representation of the surface design techniques.

5.2.1 DIGITAL BATIK

Fabric evaluation results from combined data, non-expert data, and expert data were all positive. The combined data results showed no significant difference between the digital and hand samples for two out of five batik qualities. The three batik qualities which showed significant differences for the combined results were cracking or veining, waxy lines and patterns, and halos around images. The differences found in these qualities are heavily related to the technology and the need for development in digital printing technology and software (noted previously). Also, it is important to note that only three out of the seven non-experts familiar with batik felt that halos around images were important to the batik look, and only nine out of twenty experts felt the halos were important to the batik look. Significant differences were found for the expert groups on the same three qualities from the combined results. It was apparent that a trained eye can distinguish a difference between handcrafted batik and digital batik for the aesthetic qualities of cracking or veining, waxy lines and patterns, and halos around images.

The evaluations of the expert subjects provided insight into the areas where improvements are required for professionals to be satisfied with the digital batik samples. Experts can use the techniques and processes developed here, however, for their personal exploration with graphic programs and digital printing.

For the non-experts, no significant difference was found between the hand and digital samples for all five of the batik aesthetic qualities. So, differences found in the combined data were driven by the experts in the sample. The untrained eye was unable to distinguish a difference between handcrafted batik and digitally generated and created batik. This means that digital batik created through the techniques and processes described previously could be marketed to the average consumer as a fabric with the same value as handcrafted fabrics. An advantage of digital batik fabric is that it has the potential to be produced in larger volume than handcrafted fabrics, which means it could reach a larger market. Since handcrafted batiks are not widely available, digital batik could be used to differentiate current products in the market.

It is important to note that, although the experts found differences in the aesthetic qualities, the means for the individual qualities of the digital batiks were generally positive ranging from 2.8-4.6. The means for the individual aesthetic qualities of the handcrafted batiks ranged from 3.6-4.7. Differences were found between mean expert ratings of the hand and digital batik samples in some areas, but many of the ratings were similar. The combined data, non-expert data, and expert data were all evidence to the success of the methods and techniques used to create the digital samples.

5.2.2 DIGITAL DISCHARGE

The combined results for discharge showed no significant difference between the digital and hand samples for all six of the discharge qualities. Surprisingly, the non-experts perceived a difference between the hand and digital samples for distinct pattern edges and dark backgrounds with light patterns, but it was because the non-experts rated the digital discharge samples significantly higher than the hand samples in both qualities. There seemed to be a trend for the non-experts to rate the digital samples higher than the hand samples in every discharge quality, though not all of the differences were significant. This finding is of importance because it demonstrates the average consumer may actually prefer the digital discharge fabrics over the handcrafted discharge fabrics. Since the handcrafted appearance is the goal, the fact that the average consumer prefers digital discharge over handcrafted makes for incredible marketability. It also questions the assumption that handcrafted methods offer the preferred fabric aesthetic qualities.

For the experts, a significant difference was found in only one discharge quality which was the removal of color leaving color stained patterns. To meet another aesthetic quality of discharge, dark background with light patterns, light colors had to be used in the color stained patterns. The differences seen between the digital and hand samples are most likely due to the dithering that occurred in the light colors. Again it is important to note that even though a difference was found between expert mean ratings of the hand and digital samples for one discharge quality, the ratings for the digital samples were high. The means for individual qualities of the digital discharge ranged from 3.6 to 4.4. The means for individual qualities of the hand batiks ranged from 3.7 to 4.5. This is clear evidence of the success of the digital discharge samples created through graphics programs and digital printing.

5.3 SUMMARY

The overall project was successful in determining methods and techniques for digitally generating batiks and discharged fabrics. The fabrics were extremely successful when evaluated by non-experts. Since the non-experts valued the digital batik and discharge fabrics as much as the handcrafted batik, this means that digital batik and discharge can compete with handcrafted fabrics in the mass marketplace. It also means that the quality and artistic value that is associated with handcrafted fabrics can be brought to the average consumer at a more affordable price. For the digital batik and discharge fabrics to be marketed on a large scale there is a need for digital printing production rates to increase. The digital batik and discharge fabrics can be used to in a wide variety of products including clothing, upholstery, draperies, bedding, and any other fabric related products. Using digital batik and discharge designs in products will differentiate them from other products available in the mass market.

The experts were able to see differences between the digital and hand fabrics. This is not a concern for marketability of digitally produced fabrics since experts would not likely be the target market for these fabrics. Experts are capable of producing handcrafted products themselves and see value in the process as well as the product. The experts' insights were essential in identifying the strengths and weaknesses of the digital samples. Without the experts' evaluations the true level of success of the digital samples wouldn't have been known. Experts may be inspired by this research to explore digital technologies as a means of artistic expression. Surface designers and artists can use this research as a resource for developing digital batik and discharge along with other digital surface design techniques. This research is important to textile design, textile printing, and textile art because it to pushes the limits of the digital design.

CHAPTER SIX: FUTURE RESEARH

The research presented in this study provides methods and techniques for creating digital batik and discharge fabrics that represent the aesthetic qualities of handcrafted batik and discharge fabrics. Further research could be performed in several areas related to this project.

The research project covered two of many traditional surface design techniques, so additional research is needed to explore what other traditional techniques can be created through digital means. There are several techniques like shibori, tie dye, potato dextrin, etc. that would bring interesting handcrafted qualities to digital design.

Potential markets and products for digital batik and discharge fabrics were discussed, but the marketability of digital batik and discharge needs to be fully examined. Research should be done to determine the products that would most benefit from the digital fabrics and the true market potential.

This research presented techniques and recommendations for digitally printing both sides of the fabric, but additional research is required to develop fabrics and digital printing technologies that simplify dual sided fabric printing. One option would be to create a digital printer designed specifically to print both sides of the fabric.

During the course of the research project several approaches were described for creating traditional surface design effects through graphics programs. From this exploration, a need was recognized for development of graphics software oriented toward surface designers and textile arts. Digital printing is a growing medium for surface designers and textile artists, so development of graphics programs that meet their special needs and requirements will be important.

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APPENDICES

APPENDIX A: DEFINITIONS OF TERMS

In this section, terms that are used throughout the paper are defined. Reviewing this section should clarify any terminology that is unfamiliar.

Banding: In digital printing, this term refers to visible lines on an image that are caused by a printing problem. Banding is most noticeable in printed areas that fade from light to dark.

Digital Printing: Digital printing is converting information that is in digital form into visual printed images. Textile digital printing is printing directly onto a fabric substrate from a printer that uses dyes in the form of inks.

Dithering: The term dithering is used to describe a digital printing process and the visual effect that results from the process. The dithering process is used to simulate colors that are not in the set color gamut. The process places tiny ink drops, from the available colors, onto the fabric at different values to give the appearance of additional colors. When the tiny dots are visible to the eye, the effect is called dithering.

Gawangan: A wooden frame used to stretch fabrics in preparation for the wax application in batik.

Ground Shade: In discharge printing, the color of the fabric before it has been discharge is the ground shade.

Illuminating Dyes: Colored dyes which are unaffected by the discharge paste; therefore, leave the discharged areas colored.

Pixilation: When pixels in an image don't transition smoothly, each individual square remains apparent and images are said to look pixilated.

Mordant: A substance used in dyeing to fix certain dyes (mordant dyes) in cloth.

Registration: The fitting of two or more images on the same exact spot.

Surface design: Surface design is the coloring, patterning, structuring, and transformation of fabric, fiber, and other materials (Surface Design Association, 2002).

Tjap: A tjap is a copper block with a handle that is used as a stamp to apply wax to fabric in batik.

Tjanting: Copper cups with one or more spouts attached to bamboo handles used to apply wax to fabric in batik.

Batik: Batik is a resist method of creating designs on fabric. Hot, liquid wax is applied to the fabric and then the wax cools, hardens, and cracks. The fabric is dyed and the areas where the wax is applied will not absorb the dye. The process is repeated several times to create a multicolored design. When the design is finished, the wax is removed.

Characteristics of Batik

Cracking or Veining: When batiking, the liquid wax cools and cracks. During the dyeing process, dye penetrates the small cracks creating fine random lines and veins.

Waxy lines/patterns: Because batik patterns are created with hot, liquid wax, the lines and patterns that result have a flowing liquid quality.

Halos around images: Halos are slightly darker or lighter outlines often appear around batik lines and patterns. The halos are created during the batik process due to two reasons. Halos are caused by left over wax on the fabric, or by the build up of dyes around the edges of the wax after several steps of dyeing.

Saturation of color: The dyed areas of the fabric are wet through with color.

Image on both sides of the fabric: Wax is typically applied to both sides of the fabric so that a batik image is created on both sides.

Discharge: Discharge is a method of creating designs on fabric by removing color from a pre-dyed fabric. A paste or solution that breaks down the dye is applied to the fabric, leaving the applied area slightly stained with color.

Characteristics of Discharge

Dark backgrounds with light patterns: Discharge is typically used to create light images on dark backgrounds.

Distinct pattern edges: Edges of patterns are usually crisp, and patterns are easily identifiable in discharge fabrics.

Removal of color leaving stained patterns: An additional design effect that can be created through discharge is partial removal of color creating stained patterns.

Saturation of color: The dyed areas of the fabric are wet through with color.

Varied removal of color: Discharge often varies in the amount of color removal, so the overall design may consists of white patterns along with a variety of color stained patterns.

APPENDIX B: BATIK EVALUATION TOOL

Batik Evaluation Form

Definition: Batik is a resist method of creating designs on fabric. Hot, liquid wax is applied to the fabric and then the wax cools, hardens, and cracks. The fabric is dyed and the areas where the wax is applied will not absorb the dye. The process is repeated several times to create the multicolored design. When the design is finished, the wax is removed.

Part 1: Below are some terms and definitions describing the characteristics of batik. Read all of the terms listed.

☐ **Cracking or Veining: The liquid wax cools and cracks, so during the dyeing process the dye penetrates the small cracks creating a cracking or veining effect.**

☐ **Waxy lines/patterns: Because patterns are created with hot, liquid wax, the lines and patterns that result have a flowing liquid quality.**

☐ **Halos around images: Slightly darker or lighter outlines often appear around lines and patterns.**

☐ **Saturation of color: The areas that absorb dye are wet through with color.**

☐ **Image on both sides of the fabric: Wax is typically applied to both sides of the fabric so that image is created on both sides.**

- If you **ARE NOT** familiar with batik, place a mark in the following box ☐
- If you **ARE** familiar with batik, place an X in the box preceding each characteristic you feel is important to the batik look.

Part 2: You are to evaluate four fabric samples by filling out the following four forms. Start by checking to make sure the sample number on the fabric matches the sample number in the box. Next rate the aesthetic appeal of each fabric sample according to the characteristics listed. Circle the appropriate rating.

Batik Sample # ☐	**1 not appealing 5 very appealing**				
Cracking or Veining	1	2	3	4	5
Waxy lines/patterns	1	2	3	4	5
Halos around images	1	2	3	4	5
Saturation of color	1	2	3	4	5
Appearance of image on both sides of fabric	1	2	3	4	5

Batik Sample # ☐	**1 not appealing 5 very appealing**				
Cracking or Veining	1	2	3	4	5
Waxy lines/patterns	1	2	3	4	5
Halos around images	1	2	3	4	5
Saturation of color	1	2	3	4	5
Appearance of image on both sides of fabric	1	2	3	4	5

Batik Sample # ☐	**1 not appealing 5 very appealing**				
Cracking or Veining	1	2	3	4	5
Waxy lines/patterns	1	2	3	4	5
Halos around images	1	2	3	4	5
Saturation of color	1	2	3	4	5
Appearance of image on both sides of fabric	1	2	3	4	5

Batik Sample # ☐	**1 not appealing 5 very appealing**				
Cracking or Veining	1	2	3	4	5
Waxy lines/patterns	1	2	3	4	5
Halos around images	1	2	3	4	5
Saturation of color	1	2	3	4	5
Appearance of image on both sides of fabric	1	2	3	4	5

Batik Evaluation Form

Part 3: Examine the two Batik Standards to gain an understanding of how the standards demonstrate the characteristics of batik.
Next examine the first numbered sample and evaluate how well it demonstrates the batik characteristics in comparison to the Batik Standards. Repeat this process for the second sample. Make sure the number on the fabric sample matches the number in the box. Circle the appropriate rating.

Batik Sample # ☐	**1= not at all** **5= as well as the Batik Standards**				
Cracking or Veining	1	2	3	4	5
Waxy lines/patterns	1	2	3	4	5
Halos around images	1	2	3	4	5
Saturation of color	1	2	3	4	5
Appearance of image on both sides of fabric	1	2	3	4	5

Batik Sample # ☐	**1= not at all** **5= as well as the Batik Standards**				
Cracking or Veining	1	2	3	4	5
Waxy lines/patterns	1	2	3	4	5
Halos around images	1	2	3	4	5
Saturation of color	1	2	3	4	5
Appearance of image on both sides of fabric	1	2	3	4	5

APPENDIX C: DISCHARGE EVALUATION TOOL

Discharge Evaluation Form

Definition: Discharge is a method of creating designs on fabric by removing color from a pre-dyed fabric. A paste or solution that breaks down the dye is applied to the fabric, leaving the applied area slightly stained with color.

Part 1: Below are some terms and definitions describing the characteristics of discharge. Read all of the terms listed.

☐ **Dark backgrounds with light patterns: Discharge is typically used to create light images on dark backgrounds.**

☐ **Distinct pattern edges: Edges of patterns are usually crisp and patterns are easily identifiable in discharge fabrics.**

☐ **Removal of color leaving color stained patterns: An additional design effect that can be created through discharge is partial removal of color creating stained patterns.**

☐ **Saturation of color: The dyed areas of the fabric are wet through with color.**

☐ **Varied removal of color: Discharge often varies in the amount of color removal, so the overall design may consist of white patterns along with a variety of color stained patterns.**

☐ **Removal of color on both sides of fabric: The discharge paste penetrates through the fabric removing color on both sides.**

- If you **ARE NOT** familiar with discharge, place a mark in the following box ☐
- If you **ARE** familiar with discharge, place an X in the box preceding each characteristic you feel is important to the discharge look.

Part 2: You are to evaluate four fabric samples by filling out the following four forms. Start by checking to make sure the sample number on the fabric matches the sample number in the box. Next rate the aesthetic appeal of each fabric sample according to the characteristics listed. Circle the appropriate rating.

Discharge Sample # ☐	**1 not appealing 5 very appealing**				
Dark background with light patterns	1	2	3	4	5
Distinct pattern edges	1	2	3	4	5
Removal of color leaving color stained patterns	1	2	3	4	5
Saturation of color	1	2	3	4	5
Variety of color removal	1	2	3	4	5
Removal of color on both sides of fabric	1	2	3	4	5

Discharge Sample # ☐	**1 not appealing 5 very appealing**				
Dark background with light patterns	1	2	3	4	5
Distinct pattern edges	1	2	3	4	5
Removal of color leaving color stained patterns	1	2	3	4	5
Saturation of color	1	2	3	4	5
Variety of color removal	1	2	3	4	5
Removal of color on both sides of fabric	1	2	3	4	5

Discharge Sample # ☐	**1 not appealing 5 very appealing**				
Dark background with light patterns	1	2	3	4	5
Distinct pattern edges	1	2	3	4	5
Removal of color leaving color stained patterns	1	2	3	4	5
Saturation of color	1	2	3	4	5
Variety of color removal	1	2	3	4	5
Removal of color on both sides of fabric	1	2	3	4	5

Discharge Sample # ☐	**1 not appealing 5 very appealing**				
Dark background with light patterns	1	2	3	4	5
Distinct pattern edges	1	2	3	4	5
Removal of color leaving color stained patterns	1	2	3	4	5
Saturation of color	1	2	3	4	5
Variety of color removal	1	2	3	4	5
Removal of color on both sides of fabric	1	2	3	4	5

Discharge Evaluation Form

Part 3: Examine the two Discharge Standards to gain an understanding of how the standards demonstrate the characteristics of discharge.

Next examine the first numbered sample and evaluate how well it demonstrates the discharge characteristics in comparison to the Discharge Standards. Repeat this process for the second sample.

Make sure the number on the fabric sample matches the number in the box. Circle the appropriate rating.

Discharge Sample # ☐	**1= not at all** **5= as well as the Discharge Standards**				
Dark background with light patterns	1	2	3	4	5
Distinct pattern edges	1	2	3	4	5
Removal of color leaving color stained patterns	1	2	3	4	5
Saturation of color	1	2	3	4	5
Variety of color removal	1	2	3	4	5
Removal of color on both sides of fabric	1	2	3	4	5

Discharge Sample # ☐	**1= not at all** **5= as well as the Discharge Standards**				
Dark background with light patterns	1	2	3	4	5
Distinct pattern edges	1	2	3	4	5
Removal of color leaving color stained patterns	1	2	3	4	5
Saturation of color	1	2	3	4	5
Variety of color removal	1	2	3	4	5
Removal of color on both sides of fabric	1	2	3	4	5

Part 4: Please fill out the following general information about yourself by placing an X in the appropriate box.

Sex: Male ☐ Female ☐

Age: 18-24 ☐ 25-34 ☐ 35-44 ☐ 45-54 ☐ 55-64 ☐ 65 and over ☐

Type of Employment: Professional Artist ☐ Educator ☐ Administrative, clerical ☐

Retail ☐ Executive, managerial ☐ Homemaker ☐ Student ☐ Retired ☐ Other ☐

Part 5: Thank you for your assistance with my graduate research!
Please add any additional comments in the space provided below and if there is not sufficient space continue on the back.